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metal finishing Journal

NOVEMBER, 1955



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THIS JOURNAL IS DEVOTED TO THE SCIENCE AND TECHNOLOGY OF PAINT APPLICATION, ELECTRODEPOSITION, VITREOUS ENAMELLING, GALVANIZING, ANODIZING, METAL SPRAYING AND ALL METAL FINISHING PROCESSES.

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THE GIFTIE GIE US

IT was Scotland's immortal bard who prayed so earnestly that we should be granted the power to see ourselves as others see us, and it would appear from sundry activities in recent months that more than one branch of the metal-finishing industry is striving after this kind of objective insight.

It is not many months since we referred on this page to the growing awareness of the vitreous-enamelling industry to the increasing inroads being made into its markets by other materials and finishes.

Now apparently even the electroplating industry, which is at present enjoying a period of prosperity unprecedented in its history, has seen fit to turn its eyes inward upon itself and to debate the security of its future.

This piece of introspective crystal gazing took place under very public circumstances, in fact, at the last meeting of the Midland Branch of the Institute of Metal Finishing. This meeting was devoted to a full-dress debate on a motion that plating had, in the vernacular phrase, "had it." The contributions from the floor of the meeting, although generally sincere and carefully thought out, were seldom really sombre even when at their most critical, and in many cases were completely light-hearted.

It would of course be wrong to attach any serious import to the discussion at what was certainly not intended to be a particularly serious meeting, but there were one or two points raised at the time which will bear closer examination and of which the plating industry might be well advised to take note.

Continual reference was made to the very short service life which can now be expected from the nickel-chromium plate so much in evidence on the modern motor-car, and invidious comparisons were drawn between the marked progress which has been made in improving the performance mechanically and otherwise, of all other parts of the car, and the apparent stasis which exists in relation to improvements in the performance of its plated components.

This is by no means the first time that complaints have been voiced publicly about the quality of plating on modern motor-cars, and as certain members were at pains to point out during the meeting, intensive efforts are being made, in some cases successfully, to reduce the amount of plating at present being used on cars by the adoption of such other materials as electropolished stainless iron, or chemically polished aluminium.

There was also some difficulty evident in the course of the discussion referred to above, in determining what criteria were acceptable as standards for the measurement of the prosperity or otherwise of the plating industry, and suggestions ranged from ampère-hours to supply-house dividends. We however, would like to support the view put forward by one speaker to the effect that while these figures might be indicative of present activity, they were in themselves no guarantee of continuing prosperity in the future. The only sure foundations on which a skilled technology like electroplating can build an assured future are the provision of a constant supply of trained technologists, and unremitting application to fundamental and applied research. The plating industry itself has been loud in its complaints about the poor intake of trainee personnel, and there is no lack of evidence that expenditure by the industry on investigational work is far less than is deemed desirable.

The plating industry would best serve its own ends if it were to set about putting to rights these two fundamental requirements now, at the time of its prosperity, rather than to delay action until such time as the position becomes critical. Perhaps the tabling of a recommendation at the Annual General Meeting of the Institute of Metal Finishing, held this month, urging the Council of that body to take steps towards the establishment of a National apprenticeship scheme may lead to appropriate action.

Talking Points

by "PLATELAYER"

TOPICAL COMMENT
FROM THE MAIN
LINES AND SIDE
LINES OF METAL
FINISHING

CURING A PROBLEM

WHILE a good many paints on the market are specifically designed for use on machinery and machine tools, the fact remains that air-drying paints are for the most part inferior to stoving enamels for service under the conditions prevailing where such machines are employed. Evidently, it would be difficult to put a large machine tool through an enamelling stove even in the maker's own plant, while once it is installed such a procedure becomes almost impossible. The solution to the problem seems to be in the use of portable radiant heating units. These could be mounted on castors and directed onto the machine after painting to cure the enamel and so produce a hard, oil-resistant surface. The units could be employed with advantage in most large factories, as the stoving time with infra-red equipment is very short so that the period during which the machines are out of commission would be reduced to a minimum. The intervals between successive re-paintings would also be much greater.

Although such heating units can be built up fairly readily by the user from standard elements and slotted angle-iron, there does not appear to be a commercially available portable infra-red plant suitable for this kind of work on the market.

REFLECTIONS AT THE MOTOR SHOW

ONE of the things that never ceases to surprise me at the Motor Show is the way in which the industry never looks beyond chromium plate for its hardware finishing. One would think that nothing else existed as a possible alternative. Yet chromium, for all its advantages, has a tone which blends poorly with some of the bright colours now being used increasingly in car interiors. Recently, one or two firms have rather nervously used small gold plated emblems on the exteriors of their higher-priced vehicles, and this year two manufacturers have gone a stage further. In one case an embossed aluminium fascia panel, matt anodized and dyed a buff colour looks rather attractive in its grey surround. The instrument bezels are, however, chromium plated, which is perhaps not in keeping with the rest. The other car employs silver-anodized aluminium extruded section for its door surrounds, which again strikes a new note, and should perform satisfactorily in service.

The design departments of motor firms are

seldom as well informed on the latest developments in finishing techniques and processes as the production departments; nevertheless it is necessarily the former who initiate changes in this direction, so that the possibilities must be brought to their notice. One of the snags is that sufficient plant for producing a new finish may not be available on a large scale, but unless someone creates the demand, it never will be. Motor cars could benefit in appearance by the greater use of such finishes as colour anodizing, gilding, bronze plating and vitreous enamelling; who is going to take the plunge?

WHERE WE CAME IN

WHAT is described as "a distinctive new plating process" has recently been perfected in Denmark, it is reported, and is now available in the United States under licensing arrangements. The plate is stated to be an alloy of copper and tin, remains bright and does not need polishing, and approximates to sterling silver in appearance. The deposit is especially suitable for table ware and household appliances.

This leads us to wonder whether the numerous British papers and publications of the Tin Research Council on the deposition of "speculum" alloys from 1944 onwards ever reached Denmark, and if so, whether they are known to either the sponsors of the "new" process or their potential customers. It would be too much to expect the literature to be unknown to the former, but in their own interests it is to be hoped that their customers are less knowledgeable. But perhaps they need have no fears; it has never been very difficult to sell for good money processes and information which are freely available to all for nothing.

FLYING SAUCERS

THE announcement by an American company well known in the plating field that they have developed new equipment making use of "Ionic Guns" with "Atomic Nozzles" suggests that the battle of the space-ships is about to commence.

The facts, however, are more prosaic, for these components are simply parts of an installation for the continuous electrostatic spray-coating of fabricated wire articles with plastisols. This type of covering has always been carried out by dipping, but it is claimed that greater uniformity and less waste can be achieved by the new method.

THE INSTITUTE OF VITREOUS ENAMELLERS

2nd INTERNATIONAL ENAMELLING CONGRESS

Overseas Delegates Participate in Extensive Programme of Technical Sessions and Works Visits

ON October 9 the second International Enamelling Congress held under the aegis of the Institute of Vitreous Enamellers, was launched with an inaugural dinner at which overseas delegates and their ladies were entertained by members of Council of the Institute and of the Section Committees.

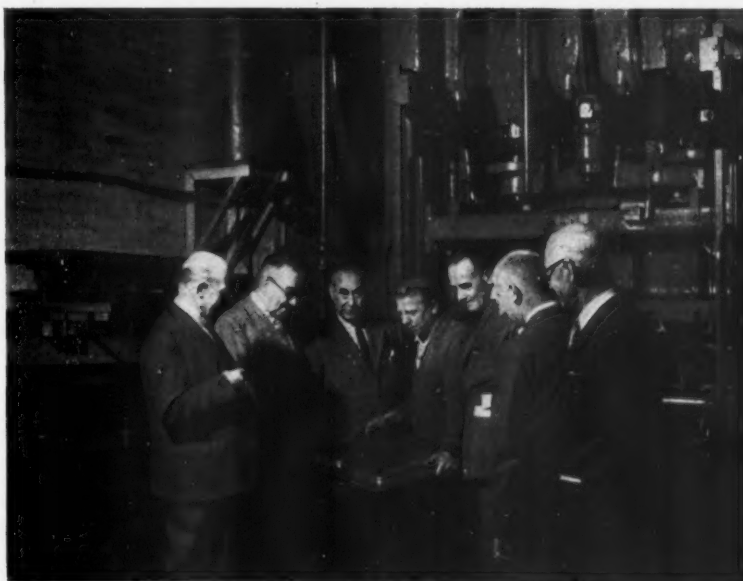
The general programme of this Congress, as published in the September issue of this Journal, comprised a comprehensive tour of enamelling works in the Southern, Midland and Northern areas of England and in Scotland, with four days being devoted to the discussion of technical papers. Hospitality was accorded to overseas delegates in the form of a reception staged by the Committee in each section and by the president of the Institute, Sir George Briggs and Lady Briggs. The two major social functions were the Congress Banquet held at Chesford Grange,

Kenilworth, on October 14, and the valedictory dinner in Edinburgh on October 21.

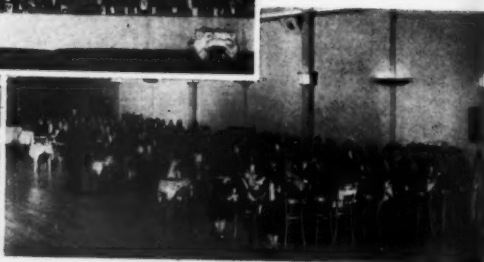
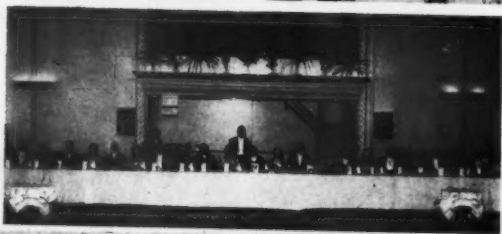
The Congress was attended by more than seventy overseas delegates in all, representative of Europe, Scandinavia, and the U.S.A., of whom more than half participated in the full programme.

On the day following the inaugural Congress dinner a full day was devoted to works visits to R. and A. Main Ltd., Belling and Co. Ltd., Benjamin Electric Co. Ltd., and Electrolux Ltd., and in the evening a reception was staged by the chairman and Committee of the Southern Section of the Institute.

On the next day members of the Congress were conveyed by coach from London to Oxford, where the day was spent inspecting the works of the Pressed Steel Co. Ltd. On leaving Oxford in the late afternoon the Congress proceeded to Leamington Spa, where it was received by the



One of the operators at the works of The Parkinson Stove Co. Ltd. demonstrates a pressing to a group of Congress visitors including (l. to r.) Mr. C. P. Stone, Mr. W. Todd, Mr. H. F. Beaumont, Mr. S. Halls-worth, Mr. A. Biddulph and Mr. W. S. Grainger.



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chairman and Committee of the Midland section of the Institute, at the Royal Pump Room.

On October 12 the twenty-first Annual General Meeting of the Institute of Vitreous Enamellers was held at the Town Hall, Leamington Spa. At this meeting the report on the year's activities of the Institute was presented by the chairman of Council, Mr. A. Biddulph.

Among the many technical activities of the Institute mentioned by the chairman, was the Summer School in Vitreous Enamelling, which had been held, as in previous years, at Ashorne Hill, on March 11 and 12. The Education Committee, under the chairmanship of Mr. J. H. Gray, had arranged a most interesting and informative technical programme, and the School had been fortunate in receiving an invitation from Fisher and Ludlow Ltd., to visit their works and enamelling plant in Birmingham. The attendance at this Summer School surpassed that of any previous year and the growing response

from industry to this activity of the Institute had been most encouraging. As a further extension of the educational activities of the Institute a number of members had co-operated by contributing to a series of lectures organized by the North Staffordshire Technical College.

The other general committees of the Institute had continued to do good work. The Library and Publications Committee, with Mr. A. McLeod as chairman, were responsible for the provision of technical papers at the meetings of the Institute, and the programme for the present Congress revealed the success of their endeavours in this connexion. This Committee was also responsible for, and gave much thought to, the assessment of papers submitted for the various Institute awards, results of which were to be announced later in the meeting, and it was a matter of some disappointment, not only to the Committee, but to the Council of the Institute, that the number of entries for the various competitions were not more numerous. Mr. Biddulph expressed the hope that those members of the Institute who were in a position to do so, would give their junior employees the fullest encouragement to enter for the awards in future years.

The work of the Technical Committee under the chairmanship of Mr. J. W. Gardom, had continued through the medium of its several sub-committees. A final report had been submitted by the Pickle Inhibitors committee, and this would be published shortly. The Atlas of Defects had been finally approved for printing, and was at that time in the hands of the printers.

Captions to illustrations on facing page

(Top, left) The president, Sir George Briggs, A.M.I. Mech.E., replying to the toast on behalf of the Institute.

(Top, right) The chairman of Council, Mr. A. Biddulph, proposing the toast of the Borough of Royal Leamington Spa.

(Centre) A composite view of delegates attending the Congress Banquet.

(Below, left) The Parliamentary Secretary to the Board of Trade, Mr. F. J. Errol, M.A., A.M.I.E.E., A.M.I. Mech.E., M.P., proposing the toast of the Institute of Vitreous Enamellers and the Vitreous Enamelling Industry.

(Below, right) The Mayor of Leamington Spa, Mr. E. A. Baxter, responds to the toast of the Borough.



A group of delegates study the dipping of gas-cooker parts at the works of R. and A. Main Ltd.

It was hoped and anticipated that this would be an interesting and important publication which would be widely sought after throughout the industry. The investigational work initiated by the Technical Committee at the North Staffordshire Technical College was still proceeding, and consideration was being given to the possibility of pursuing further lines of research and investigation.

As a result of a kind invitation from the Steel Company of Wales, the Spring meeting of the Institute had been held at Porth Cawl, from where visits had been made to the Abbey, Margam and Trostre Works, and the site of the new works, at Velindre. The visit had proved to be a great technical and social success.

Mr. Biddulph continued his report by paying tribute to the work of the local sections, which had continued to hold technical meetings throughout the session, and he welcomed the addition of the Scottish Section to their number. The Committee of the new section had drafted a full programme for the coming session and had co-operated actively in the organization of that part of the Congress which was to be held in Scotland.

The Chairman was pleased to be able to announce a slow but steady increase in membership, and he referred to the welcome which had been extended to the Institute's Bulletin, which as now appearing regularly in a new and improved format. In concluding his report, Mr. Biddulph expressed the appreciation of the Institute to the Hon. Treasurer, Mr. W. S. Grainger, for his long and zealous service in this important office. He also paid tribute to the efforts of the Secretary, Mr. J. D. Gardom, who had been responsible for all the detailed administration of the International Congress.

Following the Chairman's report, the election of certain officers took place, as follows: As President-elect, Mr. C. R. Wheeler, as Hon. Treasurer, Mr. W. S. Grainger, and as members of Council, Mr. A. Biddulph, Mr. S. E. A. Ryder and Mr. H. Whitaker.

Immediately following the annual general meeting, the first technical session of the Congress was held at which the following papers were presented. "Enamel Panels in Kitchen Units" by A. A. F. F. Buck (Belgium); "Porcelain Enamel in Building Construction in the U.S.A." by W. N. Harrison (U.S.A.).

The first technical session ended at 11.45 a.m. and immediately thereafter members were conveyed by coach to visit the works of either The Parkinson Stove Co. Ltd., J. A. Jordan and Sons Ltd., or Sidney Flavel and Co. Ltd., in each case being entertained to luncheon by the company prior to the visit. In the evening the Congress delegates were the guests of the Mayor and

Corporation of Leamington Spa at a Civic Reception in the Royal Pump Room.

The next two days were entirely devoted to technical sessions at which the following papers were presented: "Some Aspects of Vitreous-Enamelling Practice in Australia," by A. R. Williams (Australia); "Hydrogen Permeability of Steel and Its Relation to Enamellability" by S. E. Dahlgren (Sweden); "Some Observations on the Incidence of Fischscales on Enamelled Steel Pots" by Ing. E. Messmer (Germany); "Works Practice in Coloured Sheet-Iron Enamelling in Yugoslavia" by Ing. H. Ankerst (Yugoslavia); "An Investigation into the Viscosity of Enamels" by N. S. C. Millar, and C. H. Buck (U.K.); "Some Investigations into the Coefficient of Expansion of Vitreous Enamels" by N. F. Parker (U.K.); "The Development of Opacity in White Porcelain Enamels" by Professor A. I. Andrews (U.K.); "An Account of Vitreous Enamelling Practice in a Danish Works" by O. Schroeder (Denmark); "Ceramic Coatings for Use at High Temperatures" by B. Zick (U.K.); "The Establishment of Standards of Quality for Vitreous-Enamelled Ware" by J. M. Wijtenburg (Netherlands); "An Account of De-Enamelling Practice in a French Works" by J. Camuset (France); "Some Investigations into the Acid Pickling of Mild Steel" by D. Jackson, A. J. Stedman and R. V. Riley (U.K.).

On the evening of October 14, the Congress Banquet was held at Chesford Grange, Nr. Kenilworth. This was attended by nearly three-hundred delegates and members with their ladies and guests, who were received by Sir George Briggs, president of the Institute, and Lady Briggs, Mr. A. Biddulph, chairman of Council, and Mrs. Biddulph.

At the end of the banquet after the loyal toast had been honoured, the toast of the Borough of Royal Leamington Spa was proposed by Mr. Biddulph and responded to by Mr. E. A. Baxter, the Mayor.

The toast of the Institute of Vitreous Enamellers and the Vitreous Enamelling industry was proposed by Mr. F. J. Errol, Parliamentary Secretary to the Ministry of Supply, who referred to the interest of his Ministry in rendering all possible aid to those industries which were exporting to overseas markets and congratulated the Institute and the enamelling industry for the part they were playing in this respect. Mr. Errol was thanked for his remarks by the President, Sir George Briggs, who went on to convey the best wishes of the Institute to the numerous guests, both from Britain and overseas, who were present at the function.

The morning of the day following the Banquet
(continued in page 492)

The Development of SCREEN PRINTING in the Ceramic Industry

by F. E. KERRIDGE

(A paper presented at the International Enamelling Congress, Leamington Spa, October 9 to 21, 1955)

Introduction

THE screen printing process is now very well known, but a brief description of its fundamentals may assist those to whom it is unfamiliar.

A screen apparatus in its simplest form consists of a wooden or metal frame over which is stretched tautly a piece of silk bolting cloth or metal mesh. The frame is hinged to a flat base on which is placed the article to be decorated. A stencil representing the design is attached to the cloth, which is filled in with a special varnish or "screen filler", in all areas not occupied by the design. A printing ink or, in the case of ceramic printing, a vitreous enamel or ceramic colour dispersed in an oily medium, is drawn across the surface of the mesh with a rubber squeegee, and is thereby squeezed through the open portions of the mesh in the form of the design on to the surface to be decorated.

The Early History of the Process

Little definite information is available on the origins of the process. It has been suggested, probably because of the association of silk with China, that the process was used in that country in very early times, but all that can be proved is the use by the Chinese of an elementary form of open stencilling, using stencils cut from papyrus or fabric and applying liquid colour by brushing. No screen is used in this process, and ties are necessary for the stencils.

The screen process was used in the U.S.A. about A.D. 1900 and there is some evidence that it was used in Germany and Japan about 20 years earlier. Little was heard of the process prior to the first World War, but in 1920 a British patent was granted for the manufacture of carbon tissue stencils which virtually revolutionized the process and made possible the very fine work which is to be seen today. In 1930 a stencil paper was developed comprising a transparent base paper to which is attached a film of heat-softening resin, allowing stencils to be cut and affixed to the screen without ties and without losing the isolated parts of the design. This is of particular importance in the production of enamelled glass and iron signs.

Development of the process in the ceramic industries in this country can be traced back to around 1930 when it was used for glass and enamelled iron signs. By the middle '30's machines had been produced for printing on bottles, and the first screen printed transfers had been developed and patented.⁽²⁾ Development in the last 20 years, despite the interruption of the War, has been very rapid, with the introduction of automatic machines for printing on paper, glass bottles, tumblers, and ampoules, and with improvements in stencils, printing inks and pigments.

Since screen printing was first used for non-ceramic purposes such as the production of posters and showcards, it is understandable that the materials and technique employed successfully for these were borrowed for the first attempts at ceramic printing. Screen printing supply houses supplied media based on linseed and other drying oils, or purchased ceramic colour and vitreous-enamel powders and prepared screen pastes by mixing these with drying-oil type media. Although many of these pastes printed satisfactorily, the presence of drying oils in the medium resulted in unsatisfactory firings, excess carbon derived from combustion of the oils interacting with the enamels causing bubbling and discoloration. No serious attempt was made to solve this problem until ceramic colour and enamel manufacturers fully realized the potentialities of the screen process in the industries which they serve and initiated research on ceramic media. Early ceramic media, or "squeegee oils" were based on Copaiba and Tolu Balsams, cellulose-nitrate solutions in high-boiling ester solvents, and solutions of natural resins and cellulose derivatives in pine oil.⁽³⁾

The decorating processes available to the ceramic industries before the advent of screen printing (and which in many cases are still in use) were in the main capable of giving sharp outlines, and early screen prints with their "saw tooth" edges met with disfavour on this account. The definition of a screen print is influenced by the

mesh size of the printing cloth, and the type of ink, squeegee, and stencil used, but the latter has the most important effect. Vitreous-enamel powders are harder, generally coarser, and certainly more abrasive than pigments used in screen inks for non-ceramic purposes, and stencils which were quite satisfactory for posters and showcards were found to be useless for ceramic work owing to the abrasive effect of the enamels. In the glass-bottle industry in particular, where long printing runs on small and often fairly intricate designs on curved surfaces have to be undertaken, durable stencils and good definition are essential, and development of the screen process in this industry was retarded for some years owing to the inadequacy of the available stencils.

In the vitreous-enamel and glass-sign industries, however, where the designs to be reproduced are generally larger and less detailed, stencils hand cut from the paper, and later from "Profilm" (3) gave satisfactory results, and in spite of improvements in the manufacture and use of photographic stencils, are still in use.

The screen process was operated initially with enamels developed for earlier processes and no immediate necessity arose for modifying these enamels, with the exception of ensuring complete freedom from oversize gritty particles to prevent premature breakdown of the silk and stencils. In the glass industry, however, considerable difficulty had been experienced with earlier processes (notably lithographic printing and offset rubber stamping) in obtaining a sufficiently thick deposit of enamel to give a bold decorative effect on the transparent base. The enamels used for these processes were, therefore, loaded with colour base and opacifier to give strength, but other properties, in particular gloss and durability, suffered in consequence. The thick deposit of enamel made possible by screen printing allowed reduction in the opacity and strength of the enamels and a considerable improvement in their durability.

THE GLASS INDUSTRY

The screen process has developed rapidly and extensively in the glass industry, and in direct printing the most advanced techniques are employed in bottle enamelling. It is therefore appropriate to outline developments in bottle enamelling, and later more briefly to deal with other sections of the glass industry which use less advanced techniques. Screen printed transfers are used in the glass and pottery industries, and will be described separately.

Bottle Enamelling

Printing Mesh. Silk or stainless-steel cloth are the materials generally used for the screen. Nylon or phosphor-bronze cloth are used in small

quantities for special purposes. The grades of silk cloth which have been used range between 90 and 200 strands per linear inch. The more open grades allow a thicker deposit and are longer wearing but give poorer definition and less durable stencils owing to the fact that the stencils are keyed on to fewer strands than is the case with the finer mesh. With improvements in printing machines and technique, and in the grinding and mixing of enamels, resulting in less wear on the printing cloth, there has been a trend in the last few years towards the use of finer silk, usually 120 or 130 mesh. The "X.X." grade of silk in which the strands are knotted at cross-overs is normally used in ceramic printing because there is less strand movement, and consequently less stressing of the stencils than with the unknotted material.

Stainless-steel gauze has been improved considerably during the last few years, and the earlier serious imperfections in the weaving have been virtually eliminated. Owing mainly to the smooth nature of the strands and to the "crimp" imparted to the cloth in manufacture, the thickness of deposit is much greater through steel than through the corresponding mesh of silk cloth, and grades between 160 and 200 mesh allow deposits sufficiently thick for most purposes. Finer meshes up to 300 are used for special applications where extra sharp definition is required or very fine detail has to be reproduced.

Stainless-steel cloth is much more durable than silk, and does not expand and contract with variations in ambient humidity as does silk, thus allowing better colour registration. It is much more resistant to abrasion and corrosive liquids used in cleaning and in removing stencils, which if necessary can be removed by burning, and owing to the smooth non-fibrous nature of the strands allows a smoother and better defined deposit. The relatively high electrical resistance of the metal is utilized in heating screens in the thermoprinting process described later. Because of these advantages stainless-steel cloth, in spite of its higher cost, is rapidly replacing silk in bottle printing.

Phosphor-bronze cloth has been used in ceramic printing, but it has the disadvantage of stretching and yielding under squeegee pressure. This property is, however, utilized in printing on recessed bottles and in printing neck badges where a slack screen is necessary to make uniform contact with the glass.

Nylon printing cloth is available, and has smooth non-fibrous strands and some of the other advantages of stainless steel but it is not at present widely used mainly because its excessive elasticity causes breakdown of photographic stencils.

Stencils. These are of great importance and govern the quality of the printing. Stencils may

be divided into two main groups, photographic and hand cut. Photographic stencils are of two types: double transfer, where the image is formed and developed on a temporary support and subsequently transferred to the screen, and direct, where the image is formed and developed *in situ* in the screen mesh. The sharpest definition is given and the finest detail is resolved by stencils produced by the double-transfer carbon tissue or Autotype process. This process has been considerably improved in the last few years; exposure times have been reduced, dimensional stability of the images improved, and "frilling", or lifting away of the images from the temporary support has been virtually eliminated.

To operate the process a sheet of special gelatine-coated paper is sensitized by soaking for a few minutes in a dilute solution of ammonium dichromate, and is then squeegeed firmly into contact with a temporary support consisting of a sheet of transparent plastic. The sandwich is held in contact with a positive transparency of the required design and exposed to light from a mercury-vapour lamp. The sandwich is then immersed in warm water, the paper backing of the tissue peeled away and the image developed on the support by gently washing. The support carrying the developed image is then squeegeed to the under-side of the screen, image side in contact with the printing cloth, and allowed to dry. When dry, the support is peeled away leaving the gelatine stencil adhering to the mesh of the printing cloth.

Since the image is in a developed condition when applied to the screen, and not developed in the mesh, the stencil does not draw away from the mesh openings and conform to the strands as do stencils which have been developed *in situ*; thus, there are no unsightly "saw tooth" edges to the design. Since, however, the stencils are not embedded in the mesh but are only in contact, they are generally less durable than stencils developed *in situ*. The durability of this type of stencil can be improved either by chemical hardening or by protecting with lacquer, but only at the expense of definition.

The carbon-tissue stencil is most suitable for the finest quality work, particularly on flat surfaces for fairly short runs. Very long runs can only be undertaken if arrangements can be made to renew the screen at intervals. It is now seldom used in the mass production of decorated bottles.

The most durable photographic stencils are produced by coating the under surface of the screen with a solution of a light-sensitized colloid (usually polyvinyl alcohol or gelatine), allowing the screen to dry in the dark, and exposing it to light in close contact with a positive transparency of the required design. The stencil is then

developed in water (warm for gelatine, cold for p.v.a.) and the screen allowed to dry.

Stencils of this type give the familiar "saw-tooth" edges often associated with screen printing, and it is impossible to avoid this effect with stencils exposed and developed in the screen. The effect is more pronounced with silk than with metal cloth and is, of course, more obvious with larger mesh sizes. The "saw teeth" can be rendered so small as to be almost invisible with the unaided eye if a very fine mesh such as 250 or 300 is used, and there is an increasing trend towards these meshes for this reason.

A good stencil reproduces faithfully the detail in the original transparency, and the latter must be well defined with a dense opaque image in a transparent colourless surround. Manufacturers of photographic materials produce specially contrasty plates and film highly suitable for this work, but the technique of producing good transparencies from black-and-white drawings is not acquired without considerable practice.

The Medium and Colour Paste. Much attention has been devoted to the development of suitable media for ceramic screen printing. Media used for non-ceramic work in general have good printing qualities, but are often based on linseed and other vegetable drying oils which, when heated, carbonize excessively. Ceramic enamels, particularly the low-melting varieties used on glass, are sensitive to the presence of carbon in the firing process and if this is present in excess the enamels discolour and bubble.

The following major properties are required in a ceramic printing medium:—

- (i) The medium must provide a colour paste which prints thickly, and which flows sufficiently after printing to obscure the pattern of the printing mesh. The paste must not however flow beyond the confines of the design.
- (ii) The medium must fire out of the enamel without excessive carbonization, and must not leave a mineral deposit to react adversely with the enamel.
- (iii) The medium must air dry in a reasonable time, but the solvents therein must not evaporate in sufficient quantity from the screen to cause clogging of the mesh or a significant increase in the viscosity of the colour paste. Moreover, the solvent vapours must be neither unpleasant nor toxic, nor should they be inflammable.
- (iv) The medium after drying must provide a hard, non-brittle film capable of being handled and overprinted.
- (v) The constituents of the medium must be relatively inexpensive.

These requirements have been very largely met

by ceramic media now on the market which are based on solutions of natural and synthetic resins and cellulose derivatives in solvents of the pine-oil type.

The ceramic enamel powder is dispersed in the medium to form the printing paste, usually in the approximate proportion of 5 parts of powder to 1 part of medium. It is very important to ensure complete dispersion of the powder in the medium to obtain a smooth deposit and freedom from excessive flowing after printing, and most enamellers purchase the pastes ready mixed from the colour manufacturers who have the necessary equipment for efficient milling and mixing. Since printing conditions vary considerably, pastes are usually supplied in a concentrated form for thinning to working viscosity before use.

After printing on glass and other non-absorbent surfaces the impression must be either allowed to dry, or force dried, before another colour is applied. This does not apply to single-colour work which, if it can be handled in a wet condition, can be transferred direct to the kiln or lehr. Forced drying is usually carried out by passing the bottles through a heated tunnel in which there is also rapid air circulation.

The drying of prints between each colour application consumes fuel, space and time, and much attention has been given to the development of pastes which will harden on the bottle immediately after reposition. This work has been directed into two main channels, (a) use of media containing oxidizable and polymerizable resins and the application to the bottle, immediately before, or to the wet deposit immediately after printing, of a sprayed film of oxidizing or polymerizing agent, and (b) use of a heated screen and a colour paste containing medium consisting of thermofusible resins, or waxes, which solidifies in contact with the cold ware.

The problems involved in producing a satisfactory oxidizable or polymerizable medium were never completely overcome, but a large measure of success has attended the work on heated screens and thermofusible media, and the resulting "thermoprinting" process, described later in this paper, is being used extensively.

Enamels. The enamels developed for other methods of application were found to be reasonably satisfactory for screen printing but the rapid and extensive development of the process in the bottle industry has been greatly facilitated by the improvements made in glass enamels since about 1936.

A glass enamel normally has two main constituents, a low-melting lead flux or glass corresponding to the frit used in vitreous enamelling, and an inorganic colour base corresponding to the vitreous enamellers "oxide". The constituents

of the flux are melted together and quenched as in frit manufacture, and the flux is then finely ground with the colour base to form the enamel. In some enamels however, the flux is roasted or sintered at a low temperature with the base before grinding, and in others the constituents of the flux and colour base are melted together at a high temperature to form the enamel.

The main differences between enamels for glass and iron are:—

- (i) Glass enamels fuse or mature on the ware at 550-650°C. instead of 750°C. and upwards.
- (ii) Glass enamels normally contain between 40 and 60 per cent of lead oxide whereas most vitreous enamels are leadless.
- (iii) Glass enamels have a coefficient of thermal expansion of between $80 \text{ and } 90 \times 10^{-7}$, iron enamels 100×10^{-7} and upwards.
- (iv) Glass enamels are usually applied in thinner layers to a transparent base, and therefore have to contain more colour base and/or opacifier.

Glass enamels, owing to their high lead content, melt more sharply than do iron enamels, and then contract less when melting; therefore they do not have to be used in a relatively coarsely ground condition to avoid shrinkage and "crawling" of the enamel during firing. Since, however, they have a low melting point they have to be heated up relatively slowly when used with screen media to dispose of carbon derived from combustion of the medium, which if present in the molten enamel will cause reduction of lead from the latter. Glass enamels and screen media have however been developed especially for several processes now in operation in which the enamelled glass is introduced directly into the furnace at working temperature.

The same major qualities are required in glass and iron enamels. They should have good hiding power or opacity when necessary, good colour and high gloss, a coefficient of expansion closely matched to that of the ware, and good resistance to abrasion and corrosion. Enamels in use prior to the advent of screen printing had good colour and gloss, and had expansion characteristics similar to those of the soda-lime-silica glass in general use. They were, however, too high in expansion for borosilicate heat-resisting glass, and it is only quite recently that enamels have been produced which will fire on this glass without crazing or chipping.

The most notable improvement, however, has been in the durability of glass enamels, i.e., in their resistance to corrosion and abrasion. With the increase in enamelling in the glass industry, for which the introduction of the screen process was partly responsible, there arose a demand for

enamels with greatly improved durability for beer, milk and soft-drink bottles, laboratory reagent bottles, out-door signs, oven and table ware and a variety of other glass ware liable to be exposed to the atmosphere, food and mineral acids, and alkalis used in cleaning and sterilizing operations. It is not within the scope of this paper to discuss in detail the improvements made in the durability of glass enamels, some aspects of which have been dealt with in a previous paper to the Society of Glass Technology,⁽⁴⁾ and it should suffice to say that the best enamels withstand tests very similar to the British Standards Test for resistant enamels for iron.⁽⁵⁾

In assessing the progress made in improving the durability of glass enamels it is necessary to take into account their low melting point and the fact that the constituents which promote fusibility, lead, boron and alkali-metal oxides, have a detrimental effect on durability. It has always been accepted that the higher melting enamels used on pottery and iron can be made more durable than glass enamels because they can be formulated with less of the low-fusing constituents.

Precious Metals. These are more often used on ashtrays, tumblers and stemware than on bottles and are used extensively in the decoration of pottery. Gold is by far the most popular metallic finish and there are two main types, bright and burnish, both originally developed for application to the ware by brushing.

"Liquid Bright Gold" usually contains approximately 12 per cent of fine gold in the form of a solution of the sulpho-resinate in essential-oil solvents. There are very small amounts of other metals and oxides present to modify the colour and adhesion of the film. "Liquid Bright Gold", as its name implies, gives a bright mirror-like film which is extremely thin (approximately 0.000004 in.), and therefore very economical in use. It is used mainly for the decoration of the cheaper forms of pottery and glass.

"Liquid Burnish Gold" may contain 25 per cent or more of fine gold which is in suspension as well as in solution. It gives a film about five times as thick as that of the bright gold and is correspondingly more expensive in use. The film is dull and matt after firing and requires scouring with sand or burnishing with agate to give an attractive sheen.

In addition to the golds there are analogous "Liquid Silvers" which are in reality gold, platinum and palladium mixtures and which give silver-like effects.

The thick deposit given by the screen process is a disadvantage in applying precious metals since more is applied than is required for the optimum effect, and the efforts of both manufacturers and users of the products have been directed towards

providing a thinner deposit. This has been achieved by producing special "Screen Golds" of high viscosity, and by using very fine printing cloth, usually 200 or 250 mesh silk.

Printing Machines. Hand-operated and semi-automatic machines are available from several manufacturers for printing on glass bottles. With these machines the ware is generally introduced by hand into a holder or chuck immediately below the screen, which is arranged to move laterally across the surface of the ware. The squeegee is stationary above the point of contact of the screen with the ware and, of course, is located in contact with the screen mesh, forcing colour on to the ware. The latter revolves with the screen, either by contact with it, or by mechanical movement of the chuck which is synchronized with the screen.

In multi-colour work it is necessary to remove the bottle from the machine to dry the print before printing.

On flat ware, and on ware of irregular shapes, there is usually a flat side, or a corner which can be placed against a stop or into a guide, respectively, but there is normally nothing on a cylindrical bottle which can be used for registration. Some manufacturers have overcome the problem by providing, in an inconspicuous place on the bottle, (usually near the base), a pip or dimple on the glass which can be located by the operator against a guide in the machine.

In a typical layout for the mass decoration of bottles in three colours by screen printing, the undecorated bottles are loaded on to a conveyor belt which takes them to the first machine, where they receive the first colour. From this machine they pass on the conveyor through a short drying tunnel, and are cooled by a blast of cold air before passing on to the second machine. This cycle is repeated for the third colour and the bottles after inspection pass into the lehr for firing.

This arrangement can give an output of between 30 and 40 bottles per minute and requires six or seven operators, one loading the conveyor, one on each machine, an inspector and one or two at the lehr. The labour required has been substantially reduced, and the output increased, by the thermoprinting process described in the next section.

Thermoprinting. The main limiting factor in the speed of operation of screen printing particularly in multi-colour work, and in the mechanization of the process, is the necessity for drying each print before another colour can be applied. Force drying the ware by heat between each colour application reduces the time required to complete the decoration of a bottle, but this operation requires space and is relatively costly, and does not allow the use of automatic machines printing colours in rapid succession with the

resulting saving in labour and space.

In 1947 a British patent⁽⁶⁾ was granted to Rockware Glass Ltd. of Greenford, Middlesex, covering a process which, with developments in the last few years, is likely to revolutionize the mass decoration of bottles. The process comprises the heating of the screen, squeegee and colour mixture by radiant heaters enabling a thermofusible medium to be used in the colour mixture which, under the influence of heat, is fluid on the screen, but solidifies almost instantaneously on the cold bottles. Paraffin wax, resins and oil are mentioned as suitable constituents for the medium.

The same company has developed a fully automatic printing machine embodying the process. This machine receives the bottles from a conveyor and places them automatically into chucks which are kept in register with a number of screen holders as they pass through the machine. As each bottle approaches the screen a squeegee is tripped and this moves at the same lateral speed as the bottle which rolls under the screen. Finally, a "take-out" mechanism removes the printed bottle and places it vertically on a conveyor taking it away to the lehr. The machine can print a two-colour neck label on a bottle simultaneously with a three-colour body label with operating speeds of up to 50 per minute. On this basis the machine could displace twelve of a semi-automatic type with a 75 per cent saving in direct labour costs and floor space.

Other machines for use with thermoprinting enamels have been developed abroad although few, if any, incorporate fully automatic loading and unloading. A machine produced in France⁽⁷⁾ operates on the turret principle with the printing heads arranged in a semi-circle. In this machine the metal mesh of the screen is used as the heating element with additional elements in the squeegees. The same manufacturer also produces a variety of machines for cold printing on glass ampoules, tumblers and ashtrays, and on pottery.

The use of these machines has been made possible by the development of satisfactory thermoprinting enamels. At one time it seemed likely that development of the process might be retarded because of the poor printing and firing qualities of the early enamels, but intensive research has resulted in the production of enamels which have the basic qualities of the cold printing type in addition to fluidity on the screen at a suitable working temperature (approximately 70°C.) and solidification on the cold bottles.

The introduction of thermoprinting has resulted in a search for squeegee, screen filling and stencil materials which will withstand the elevated temperature at which the process is operated. The use of the metal screen mesh as a heating element in particular imposes a severe strain on

gelatine and polyvinyl alcohol stencils which are in intimate contact with the source of heat, and although satisfactory printing runs can be obtained with these stencils when they are properly made, alternative materials are being investigated which are less liable to embrittle when heated.

Screen Printed Transfers for Glass

The first screen printed ceramic transfer was developed in 1936 for the glass industry, and has played a notable part in the improvement and development of glass decorating. The transfer comprises a porous paper backing to which is attached, by means of a water-soluble gum interlayer, a thin film of a cellulose ester which carries the design in screen-printed enamels. In use the transfer is soaked in water which softens the gum interlayer and allows the cellulose support film carrying the design to be slid face upwards on to the ware. Surplus air and water are removed from between the support film and the ware by means of a squeegee, and the ware is ready for firing.

The screen transfer has certain advantages over the direct screen process. A design can be printed in many more colours than is practicable by direct printing, definition and registration of the colour is better, and transfers can be applied to ware of irregular shapes unsuitable for direct printing. Transfers can be applied by relatively unskilled labour, and the cost of printing machines, and screen and stencil manufacture is avoided by the user.

The direct screen and transfer processes are to some extent complementary since simple designs in one or two colours can be efficiently, and probably more economically, applied by direct screening, but more intricate designs carrying more colours to give a superior decorative effect can be applied by screen transfers.

Developments in transfers, have been mainly in the direction of more careful designing for the process, introduction of burnish gold transfers with or without enamel, and of transfers printed in translucent satin surface enamels to give cameo effects.

THE POTTERY INDUSTRY

Screen Printing Direct on to Pottery

The direct screen process is developing very slowly in the pottery industry in this Country, and the main reasons for this are that the registration and definition of screen printing direct on to pottery is not good enough to give the high-quality decoration generally required by the industry. In addition the wide variety of shapes and sizes of ware produced throughout the industry imposes difficulties in the development of printing machines.

Imperfections in definition and registration which would be unnoticed on a transparent base such as glass become painfully obvious on a white pottery background, and a higher standard is therefore required for pottery. Furthermore, the screen process has to compete in the pottery industry with established processes such as copper plate and lithographic printing in transfer form, which give sharp outlines, and in the case of the latter, close colour registration.

The direct printing process finds more use in the pottery industry in the United States than in England, mainly because in the former country, owing to the nature of the market, more ware is produced of a standardized size and shape. In England the direct printing process is likely to be confined to the decoration of tiles, and of the cheapest earthenware in simple one and two-colour designs.

Printing on pottery can be carried out under-glaze or on-glaze. In the former the print is made on to the "biscuit" or un-glazed body using pigments which contain very little flux or frit; after decoration the ware is coated with glaze by dipping or spraying and fired at a high temperature (usually about 1,000°C.) which fuses the glaze over the decoration. Since it is protected by the glaze, under-glaze decoration is more durable than on-glaze, but owing to the high temperature which the colours must withstand the palette is much more limited. In the case of under-glaze decoration of earthenware, the porous "biscuit" body immediately absorbs the medium from the printing paste, resulting in almost instantaneous hardening of the impression, and allowing other colours to be applied immediately, as in the thermoprinting process. This does not occur with china, which has an impervious vitrified body.

"On-glaze" printing on pottery is carried out in much the same manner as on glass and vitreous enamel, and similar media are used. The enamels are based on lead-borosilicate fluxes, and resemble the more resistant of the glass enamels except that they mature at higher temperatures, 700-800°C. instead of 550-650°C.

Screen-printed Transfers for Pottery

The limitations already mentioned attending the screen process used direct on to pottery, and which limit the usefulness of the process in the industry, do not apply to screen transfers which can be applied to irregularly shaped ware and to curvatures on which direct printing is impracticable. They are available in on-glaze enamels with or without burnish gold and platinum, and the number of colours in a design is limited only by economic considerations. The definition, colour registration, and general decorative effect of the transfers is of a very high order, and they probably

represent one of the best examples of advanced screen-printing technique.

Although at present screen transfers are considerably more expensive than those of the lithographic type, they are finding increasing use in the Potteries. One of the reasons for this is that by virtue of their thick enamel deposit they provide a decoration which stands in slight relief on the glaze, and which often has more brilliance and "punch" than lithographic designs which are very thinly printed. This relief effect closely resembles hand painting which of course, is a much more costly process. Furthermore, they are produced in enamels which are all of a uniformly high standard of resistance, whereas owing to the thin deposit inherent in the process, lithographic transfers must be printed in enamels of high tinctorial strength which is in most cases incompatible with good durability.

The "water slide" method by which screen transfers are applied is quicker and easier and requires less skilled labour than does the "stick down" method used for lithographs. This latter process, however, has been used in the Potteries for very many years, and it is probable that the improved durability and different decorative effect are at present more significant factors in the widening use of screen transfers than is the method of application to the ware. With rising labour costs and increasing shortage of skilled labour, however, the "water slide" method of application, with the improvements which can be expected, is likely to become a very important factor in favour of screen transfers.

THE FIRING OPERATION

Decorated glass, pottery and enamelled iron are fired in the temperature ranges 550-650, 650-800, and 800-900°C. respectively, the precise temperature depending largely on the type of glass, pottery glaze and iron enamel used.

The firing operation for glass and pottery usually occupies several hours owing to the necessity for taking the ware slowly up to the temperature and cooling it slowly to avoid strain and breakage through thermal shock. Providing the ware has reached furnace temperature it is necessary to keep it at or very near peak temperature for a period of only 20-30 minutes to allow the enamels to acquire maximum gloss and to smooth out the impressions of the mesh produced in screen printing. A more prolonged soak at peak temperature can have a harmful effect in causing devitrification of the enamels, which usually results in scumming of the enamel surface, or in complete loss of gloss.

Enamelled iron is fired at well above the minimum temperature required to melt the base enamel and decoration, and the period at peak

temperature therefore has to be restricted to a few minutes to prevent excessive flowing and diffusion of the enamels.

A wide variety of decorating furnaces are used in the ceramic industry, but there are certain basic requirements in the firing of screen-decorated ware to which well-designed furnaces conform. The furnaces have accurate temperature measurement and control, and if of the travelling lehr type have controlled variation of belt speed to accommodate variations in the size and load of ware. Adequate ventilation is of great importance to ensure rapid disposal of fumes arising from combustion of screen-printing media and transfer films, and to provide an oxidizing atmosphere for the oxidation of carbon derived from the media. Electric furnaces, although considered to be more expensive to run, are increasing in favour because they are easy to control, are clean, and present no difficulties in disposing of the products of combustion of fuel.

Gas and oil firing are still used quite extensively, particularly for batch-type furnaces firing sheet glass and for pottery, but unless the firing chamber is muffled, or well draughted, the products of combustion, which often have a high sulphur content, may adversely affect lead-containing enamels, and will certainly impair the brilliance, and possibly the adhesion of gold and platinum decoration.

Coal firing is still being carried out in the Potteries, but is being rapidly replaced by gas and electricity, with improvement in the quality of the ware and a reduction in the air pollution of the district. In coal firing the ware is placed in refractory "saggars" which protect it to some extent from the products of combustion of the fuel.

THE VITREOUS-ENAMEL INDUSTRY

Screen printing has developed less in this than in the other two branches of the ceramic industry, although it was introduced at about the same time as in the glass industry. It is used mainly in the production of out-door signs, and badges, scales and other markings on small panels for affixing to stoves, gas and electric heaters, telephones and meters.

Some methods used for the production of vitreous-enamel signs are somewhat laborious and wasteful in materials, and it is surprising that screen printing has not replaced them more extensively, but, as in the pottery industry, techniques have been built up over the years, and there is a natural reluctance to abandon well-tried methods, which in many cases give an excellent product. The competition, however, which the vitreous-enamel-sign industry must be experiencing from toughened glass, plastic, and stove-

enamelled iron and aluminium signs, with the gradual retirement of staff versed in the old techniques, should add impetus to the changeover to screen printing.

It is not suggested that screen printing can replace every other method of decorating, and in the production of large signs for instance, where a considerable area has to be covered with enamel and the design is relatively simple, the airgun spraying process with suitable masks is probably a better proposition than screen printing. However, the author has witnessed the production of signs which involved the application of several coats of enamel over the entire surface of the panels by dipping and spraying, the laborious cutting of several complicated masks, the removal of overspray from around the masks with a scraper, and several firing operations. Screen printing could have been used with a considerable saving in time, labour and materials, and the elimination of all but the final firing operation.

The technique of printing on enamelled iron is much the same as on flat glass, but if the enamel is based on a leadless frit it must be relatively coarsely ground to avoid excessive shrinkage during firing, and this necessitates the use of fairly large-mesh printing cloth and robust stencils. Leadless frit is normally used with a low percentage of colour oxide, and a very thick deposit of enamel is necessary to obtain adequate colour strength and opacity in the enamels.

The main difference between vitreous enamel and glass and pottery decorating lies in the firing technique. When enamelled glass and pottery are fired the underlying glass and glaze may soften slightly, but they do not melt. When enamelled iron is fired the enamel underlying the decoration becomes completely molten. This necessitates a very close control of the temperature, and particularly the time, of the firing operation which must be restricted to a few minutes while the enamel is molten, otherwise diffusion will occur of the base enamel into the decoration, which will lose its sharpness of outline and weaken considerably in colour. A longer heating-up and cooling-down period is required for pottery and glass owing to the relatively poor resistance of the ware to thermal shock, but since the peak temperature at which the decoration matures is below the melting point of the base, the period at which the ware is maintained at this temperature is not nearly so critical as it is with enamelled iron. As a result the quality of some types of decoration, notably screen and lithographic transfers, is consistently better on pottery and glass.

There would appear to be three main reasons why it is usual to re-fire the base enamel during the decorating fire of enamelled iron:—(1) the enamels used for the decoration are of the same type and

have approximately the same melting point as the base enamel, (2) if the ware is fired at the softening point, but below the temperature of complete fusion, blisters and other defects appear in the base enamel, and (3) it is convenient to use the same furnace at the same controlled temperature for firing the base enamel and for decorating.

The most important advantages of the present method are the use of the one furnace, and the very rapid firing cycle. The disadvantages are (1) the difficulty of maintaining sufficiently close control of time and temperature for optimum quality of decoration, (2) re-melting of the base enamel increases the liability of the ware to firing defects caused by "boiling", kiln dust, etc., and (3) the molten base enamel exerts stresses on thinly printed decoration, particularly transfers and bright and burnish golds, resulting in cracking, and in severe cases complete break up of the decoration.

In the past, decorative enamels made to mature at a lower temperature than the base enamel were of considerably lower durability, but with recent advances in formulation, lower fusing enamels of satisfactory durability could be made available. A lower decorating fire might therefore be practicable, and would give sharper outlines and clearer details to the decoration, less cracking in the enamel or gold decoration, fewer rejects through defects developing in the base enamel, and a more extensive colour palette, particularly on titania-opacified base enamel, where fusion of the enamel has a deleterious effect on many superimposed colours.

CONCLUSION

Screen printing has developed rapidly in the glass industry, where its advantages of thickness of deposit and economical operation can be matched by no other process. Its use, both direct and in transfer form, has resulted in an enormous increase in the production of enamelled glass, particularly of containers, tumblers, stemware and glass signs. Future developments are likely to be improvements in quality and a reduction in costs resulting from mechanization of the printing operation made possible by the introduction of the thermoprinting process.

Development in the pottery industry of the direct printing process has been slower because of several factors, the most important of which are limitations imposed by the variety and shape of the ware and the existence of other processes which, although more laborious in operation, give better definition and registration. The development of the direct process seems likely to be confined largely to the printing of single and

simple two-colour designs on ware of standardized shape.

Screen-printed transfers do not suffer from the limitations of the direct process since they are printed on a flat surface and can be applied to irregular shapes. They are finding increasing use in the Potteries and the improvements which have been made in the short time they have been available would suggest that further development can be expected.

The direct screen process is used in the vitreous-enamelling industry mainly in the production of signs and badges. It is seldom used purely for decoration owing to the utilitarian nature of most enamelled ware.

The use of plastic in the kitchen is increasing, largely at the expense of enamelled iron; this ware is often more expensive and less durable and presumably sells because it is colourful and decorative. The greater use of screen printing and other decorating processes to enhance the appearance of enamelled iron ware might provide an answer to this competition.

The existing method of firing decorated enamelled iron, in which the base enamel is re-melted does not give consistently good results with transfers and imposes difficulty in the use of liquid gold and other metallic and lustre decoration. A modified firing technique in which the base enamel is not re-melted might be practicable and might improve the quality of decoration and make available an extended range of decorative effects.

References

- (1) British Patent 471,219.
- (2) U.S. Patent 2,379,507.
- (3) A proprietary stencil paper using heat-softening resin as the adhesive.
- (4) Kerridge, F. E., "Improvements in Glass Enamelling," *Soc. Glass Techn.*, 1951, 35, pp. 96-112.
- (5) British Standard No. 1344: 1947.
- (6) British Patent 616,827.
- (7) Machines Dubuit, 60 Rue Vitruve, Paris 20e.

DISCUSSION

The CHAIRMAN (Mr. W. Thomas) congratulated the author on giving a very able exposition of the screen printing process. He said that his firm had carried out a considerable amount of work on the printing of large dials for meters, where accuracy was essential. Photostencils were used, and the biggest drawback was the cost of the screen, in that high fidelity of printing was seldom obtained after 200 to 300 impressions. He had been very interested to hear the author say that the cost should be between 2d. and 3d. per impression. In his opinion it was the life of the screens which made the process so expensive. Most of the dials to which he referred

had to be domed to enable them to keep their shape, and the skill required of the operator in using a silk screen and getting a complete impression in one sweep of the hand was quite considerable.

The author referred to screen printing on transfer paper and then transference on to vitreous enamel. His company had tried this in some instances, and there was a curious effect which he would like the author to explain. The transferring was quite successful, and after firing a perfectly good print was obtained, but the enamel ground seemed to be drawn, as though there were more strength in the transfer film than in the actual surface of the enamel, so that while the print was satisfactory the enamel surface was quite spoilt.

Mr. KERRIDGE said that the poor durability of stencils of the photographic type was common not only to the vitreous-enamel industry but also to the glass industry, especially where thermo-printing was being undertaken. It really depended on the definition and accuracy of registration required in the stencils. If very fine definition and very close accuracy were needed, the double transfer or autotype of stencil was necessary, and this had poor durability. The durability could be improved a little by coating with lacquer or by treating with tanning agents such as potash, alum or formalin, but neither of those expedients effected much improvement. If, however, a little less accuracy could be tolerated, one of the direct-application type of stencils was indicated. One which was used throughout the bottle industry was that in which the screen was coated with a solution of polyvinyl alcohol, sensitized with dichromate, and the stencil was developed *in situ*. Another process also used in the glass industry was that in which fairly substantial sheet gelatin, coloured, such as was used in spotlights for theatricals, was sensitized and applied to the screen and again developed on the screen. Both of these stencils were far more durable than the double-transfer type.

The second point concerned screen printing on to transfer paper and subsequent application to vitreous-enamelled iron. The transfer paper was one of the governing factors in the production of screen transfers. Some types of transfer paper which gave good results were unfortunately patented, though one of the patents was due to expire in the next year or so. The other governing factor was the type of enamel used. If it was a leadless frit with a small amount of colouring oxide there was usually some contraction of the enamel during the firing process, and this could give rise to defects. Moreover, these leadless frits had a very long softening range, which did

not allow the carbon to burn out before the frit started to soften. Many of them, he believed, softened at about 600°C., and it was quite possible for the carbon to exist at this temperature.

A SPEAKER asked what were the difficulties in using screen gold and how they could be overcome.

Mr. KERRIDGE replied that screen gold was a fairly recent development. It had first been developed for the glass industry, and the first screen golds which were put on the market had been far from satisfactory. Today most of the problems connected with screen gold for glass had been solved, but its application to enamelled iron was far more difficult than its application to glass, chiefly because of the very rapid firing which enamelled iron was given but also, probably, because of lack of oxidizing conditions in the furnace. There was a case to be made, he believed, for firing screen gold on to enamelled iron at a much lower temperature than that conventionally used, but this involved other problems in relation to defects in the base enamel. Possibly the screen gold which the speaker had tried had been made for glass or pottery, and not specifically for enamelled iron. It would be useful to ensure that it had been made for enamelled iron and not for glass or pottery.

The SPEAKER said that the firm which had sent the sample had emphasized that they had not enough experience themselves. The firing was done in an electric furnace and the defects had been apparent; there was no gloss and the colour was rather black. He had thought that the gold layer was too thick, and therefore had tried not screening it but stamping it with rubber. The result had been a little better in some ways but not really satisfactory.

Mr. KERRIDGE said it was important that screen gold should be applied very thinly, and it was always advisable to use a very thin mesh silk for applying the gold; 25-mesh or even 30-mesh silk was available and should always be used for this purpose.

Dealing with a further question, of how the results obtained with transfer papers could be improved, he said he assumed that the transfers referred to were made for enamelled iron and not for glass or pottery. The application of the slide-on type of transfer to enamelled iron had to be carried out very carefully. All the moisture and air must be expelled from the film, and it was very important that the ware carrying the transfer should be dried before being fired. It was surprising how much moisture the cellulose types of film could absorb. Acetates could absorb, for instance, as much as 8 per cent of moisture,

and some hours must be allowed for that moisture to dry on the film.

Mr. D. BREARTON (Electrolux Ltd.) said that in the paper it was stated that "liquid bright gold" usually contained about 12 per cent of fine gold in the form of a solution of the sulphoresinate in essential oil solvents, but later in the paper the statement was made that sulphur might adversely affect lead-containing enamels, "and will certainly impair the brilliance, and possibly the adhesion, of gold and platinum decoration." Would the author outline briefly the reasons for using a sulphur compound rather than any other? Second, was the trend in development towards alkali resistance or acid resistance?

Mr. KERRIDGE said that so far as sulphur in the gold was concerned, it was an essential constituent of "liquid bright" and "liquid burnish" gold. It was present not as elemental sulphur but as a complex sulphur resinate. It was impossible to produce a "liquid gold" without first of all producing what was called "sulphur balsam," a complex of sulphur and organic resin, and the gold chloride was subsequently reacted with this sulphur balsam to form a gold complex which, however, broke down very rapidly in the firing operation, usually at below 200°C., and the sulphur dispersed very rapidly. Sulphur which was present in the later stages of the firing operation, at around the maturing temperature of the gold decoration, could certainly be harmful.

Continuing, Mr. Kerridge said that both acid and alkali resistance were extremely important, alkali resistance mainly for returnable containers such as soft drink bottles and beer bottles, where the bottles were put through a drastic cleansing and sterilizing operation using basic sodium phosphate and caustic soda and boiling water; this treatment would have a bad effect on a non-resistant enamel. Acid resistance was more important for domestic glassware which was likely to come in contact with foodstuffs.

Acid resistance was also necessary to prevent tarnishing in industrial areas, particularly in the case of enamelled glass signs.

Mr. F. OESTERLEN (Wurtembergische Metallwarenfabrik, Germany), who said that his firm would like to start using screen printing on enamel ware, asked whether the author would recommend silk screens or stainless-steel screens and how many prints could be made from one screen.

Mr. KERRIDGE replied that undoubtedly metal screens were to be recommended for vitreous-enamel printing. They withstood the abrasive effect of the enamel more satisfactorily than did silk, they were easier to clean, and they

had other advantages, in dimensional stability etc. and very long life. Usually a metal screen failed not because it wore out but because an operator put a palette knife through it or some accident happened to it. The stencil to be recommended for vitreous enamelling on a stainless-steel screen was certainly polyvinyl alcohol. A silk screen was usually less taut and springy than a stainless-steel screen, and therefore in the printing of ware which was not quite flat a silk screen was easier to manipulate. Much ware, in fact, could not be printed with stainless-steel mesh owing to the tension of the screen, and in that case silk, nylon, or in some cases, if screen durability was important, phosphor-bronze, which had less tension and less snap than stainless steel, was used.

Mr. A. BIDDULPH (Ferro Enamels Ltd.) said that "liquid gold" as made up was a dark brown colour, and when used on white or light colours there was no difficulty in seeing it; gold however showed up to its greatest advantage on black making it difficult to check mistakes until after firing. Was it practicable to make up "liquid gold" with a white pigment?

Mr. KERRIDGE replied that the poor visibility of "liquid gold" on a dark surface was a problem, but it was impracticable to introduce a white pigment, because it would remain present in the firing. However, some fairly promising results had been obtained by introducing into the "liquid gold" a dye, which fluoresced under the influence of ultraviolet light. Experiments had been conducted using ultraviolet light over the ware, and the "liquid gold" in those circumstances was visible.

Mr. W. S. GRAINGER (Stocal Enamels Ltd.), commenting on the author's reference to the abrasive action of the enamel base, asked whether he could give a total production figure for a 2-ft. × 3-ft. sign using ordinary silk, and whether the weight of material left on the plate was due to the mesh size or the thickness of the silk.

Mr. KERRIDGE said that it was difficult to give a reliable figure as it depended very largely on the fineness of the vitreous enamel and on the freedom of the enamel from over-size particles. Theoretically the enamel should contain no over-size particles, but in practice they were sometimes present. In the glass industry, however, 100 to 150 gross of glass bottles were printed satisfactorily from one silk screen.

The thickness of the screen deposit was not governed by the mesh size of the material but by the thickness of the printing cloth and partly by the crimp which had been imparted to the printing cloth in manufacture. One reason why stainless-

(Continued in page 488)

U.S. WORKS TRIES DUSTBLASTING FOR HIGH QUALITY CHROMIUM PLATE

By T. A. DICKINSON

A NEW and unusual production set-up now enables the Ryan Aeronautical Company at San Diego, Calif., U.S.A. to produce a higher quality chromium plate on the internal surfaces of rocket engines, despite the fact that time and overall production requirements have been substantially reduced.

Chromium, with its high melting point, 3300° F. (1815°C.), is used to protect the base material of the rocket motor from the heat generated during its short-lived period of thrust and to prevent corrosion by the chemicals used in the rocket's fuel system.

In the past, the company depended on outside processors for this type of work. This arrangement, while satisfactory during the initial phase of limited production, became unwieldy because of the problems and expense involved in shipment and inspection. Therefore, it became necessary for the company to establish its own facilities.

Ryan chromium plating facilities and the plating processes used were engineered by the company's chemical engineering laboratory under the direction of the chief chemist, Mr. Bernard Floersch.



Fig. 1.—Specially designed portable hopper being filled with fine sand for blasting interior of rocket engines prior to chromium plating.

The plating operation itself is comparatively simple. The motors are dustblasted and placed on special racks then lifted on a monorail hoist and immersed in a chromium plating bath. They are plated for eight hours in a new high speed chromic acid solution at a temperature of 120° F. (50° C.).

After the plating operation, the motors are rinsed in cold water and again in hot deionized water to remove all stains. In the event that one



Fig. 2.—Dust-blasting operation in progress on the internal surfaces of a rocket engine.

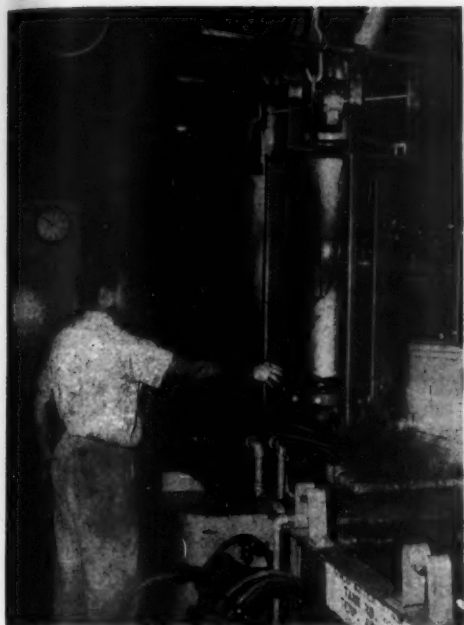


Fig. 3.—The rocket engine and its specially shaped conforming anode mounted into its rack being lowered into the chromium plating bath.

does not pass inspection, the plating is removed in a stripping tank containing hot caustic soda and rinsed in hot water. Then it is prepared for plating again.

One of the major problems involved in the process is maintaining a constant thickness of

chromium throughout the full length of each hour-glass-shaped motor. The motor's interior must be plated to a thickness of 0.007 in., plus or minus 0.001 in. This must be done without removing the motors from the bath until the required thickness is reached.

To obtain this uniformity of thickness, in spite of intricately formed inner cooling passages, it was necessary to design a conforming anode, *i.e.*, one which would parallel the curvature of the inner walls of the motor. Only by maintaining a constant distance between anode and wall can a constant thickness of plating be achieved. Close watch over the plating operation is also necessary to assure proper thickness.

Another problem was that of dustblasting the motors in preparation for the chromium plating bath. In order to achieve the best plating, the motors must have a smooth surface, free of pits and nodules, metal oxides and organic contaminants. This is accomplished by first dustblasting, then hand-sanding the motors.

The sand most commonly used for sandblasting at Ryan is of 36-mesh coarseness. This was far too heavy to use on the rocket motors since it produced a very rough surface and often caused warpage. Consequently, it was decided to use sand from the dust collectors in the blasting booths, after it had been broken down in processing exhaust manifolds.

While the dust proved satisfactory in many respects, it still caused some pitting on the rocket motors. These small blemishes had to be removed by a rather lengthy hand sanding operation before the motors could be plated. A screen analysis showed that the dust still con-

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Fig. 4.—Final inspection for thickness of deposited chromium. This must be 0.007 in. with a tolerance of ± 0.001 in.

Maintenance and Repair of Machinery of the Fleet

SOME interesting information on naval maintenance practice was given in a paper entitled "Changing Pattern of Maintenance and Repair of Machinery of the Fleet" presented by Rear Admiral John E. Cooke, R.N. at the Summer Meeting of the Institution of Mechanical Engineers in Southampton on July 7.

In describing some of the new processes and techniques which have been developed and applied the author referred to a number of metal surface treatments.

Chemical Descaling

Chemical descaling of heat exchangers on the sea-water side by circulating through the tubes a diluted proprietary cleaning agent consisting of hydrochloric acid, phosphoric acid, and a suitable inhibitor has been developed for safe and satisfactory use in main and auxiliary condensers and drain coolers. Any ferrous parts in a system are first protected with a rubber-based paint and arrangements are made to ensure that the acid cleaning agent is contained entirely in the sea-water side of the heat exchanger. After circulation for about 4 hours, the acid is left to stand in the system overnight, and recirculated the following day until gassing ceases. It is then removed and the system flushed through with fresh water. The results have been most satisfactory, there have been no cases of tube-plate or tube attack and, in the case of badly scaled main condensers, vacuum has been restored to the design figure. The saving in time, labour and cost compared with de-tubing, descaling in an acid bath or replacement of the tubes by new ones, followed by re-tubing, is vast. Another tool of maintenance has been forged.

Electrolytic De-rusting

Electrolytic de-rusting has been further developed by members of the Royal Naval Scientific Service, working at the Central Metallurgical Laboratory attached to Portsmouth Dockyard and in the dockyard, in particular in its application to machinery parts *in situ* such as the interior of turbines. This process, originally developed by Colonel Cox of the United States Transportation Corps for de-rusting cargo tanks by passing a low-voltage high-amperage current through an electrolyte of common sea-water with the article to be cleaned arranged as the cathode in the circuit, was first used at Portsmouth to successfully de-rust the interior of a high-pressure

turbine in H.M.S. *Indomitable*, using a generator in the ship supplying 300 amperes at about 12 volts, and a dilute solution of caustic soda as the electrolyte which does not attack parts subject to sea-water attack such as stainless-steel blading. The process is now in use in the Factory in Portsmouth Dockyard for cleaning turbo-generator turbine rotors and casings, and at the time of writing is being used for cleaning the low-pressure turbine of H.M.S. *Armada* using in this case a further development in the electrolyte to obtain easier separation of rust deposit from that most difficult position, between the blades. The action depends upon hydrogen gas being generated at the cathode by decomposition of the electrolyte by the current. The hydrogen so produced has a reducing, scouring and lifting effect on the rust as the action takes place at the interface of the rust film and the parent metal. Another successful example of the use of this process in the maintenance of ships is the removal of rust from decks, prior to preservation for reserve, by applying iron-mesh electrodes contained in canvas bags filled with sea-water and passing a current between the deck and the anode electrode. There are other uses in the maintenance field.

Deposition of Metals

The practice of deposition of metals to restore worn or corroded parts had been developed. Metal spraying using mild-steel, stainless-steel, zinc, aluminium, copper and brass wire is employed freely for building up static parts such as ball races to restore fit on shafts and in housings, and for protective purposes. Its use on dynamic parts is confined to items where if failure of the deposited metal occurred, the results would not be unduly serious. Examples of this are turbine rotor shafts in way of carbon glands. The general run of dynamic parts are built up by electro-deposition. This is more costly and takes longer than metallizing and with current advances in metallizing practice, the use of the latter is now being considered for dynamic parts such as turbine rotor journals where failure could be disastrous. Electrodeposition is also used to put hard surfaces on working parts and restore this surface when worn. Metal spraying using metallic powders is at present confined to coating parts for protective purposes.

In the post-war years there has been much
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Some Experimental Findings on the

COLOUR STABILITY

OF

"FRITTED-IN" COLOURED ENAMELS

By N. S. C. MILLAR*

Summary

Coloured enamels having clean bright tones and improved stability to firing variations may be made by smelting into a titanium frit compounds of colouring elements, e.g., chromium, copper, cobalt, manganese or nickel, or combinations of such elements. The role of cobalt in the production of one of these colours is discussed, and the influence of frit composition on colour is described.

Under certain conditions, it is also possible to obtain a metallic lustre finish by recrystallization of copper and manganese compounds.

Introduction

It is well known that the use of natural rutile in a titanium self-opacified frit yields a cream-coloured enamel on firing, this colour being due to the chromium content of the mineral rutile. The influence of similar colouring elements smelted into a titania enamel appeared to be a logical development worthy of investigation.

A disadvantage of coloured titanium-opacified enamels, prepared by the orthodox method of adding colouring oxides to the mill, is their relatively low stability to variations in firing times and temperatures. It was reasoned that by incorporating the colouring compounds in the frit, greater stability would result.

Experimental

Three base frits were used in this investigation, namely:—

1. 2155—An anatase TiO_2 self-opacified steel enamel.
2. 212—An old-type rutile-opacified TiO_2 self-opacified enamel.
3. 231—A clear acid-resisting TiO_2 steel enamel

One-kilogram batches were smelted in a gas/compressed-air crucible furnace, at 1200°C . until batch free, then quenched in water and dried. The usual percentage mill addition was:—

Clay	5
Bentonite	$\frac{1}{2}$
Potassium nitrate	$\frac{1}{4}$
Sodium aluminate	$\frac{1}{4}$
Water	45

The slips were sprayed onto groundcoated steel panels 3×2 in. \times 16g. to an application weight of 24 gm. per sq. ft. dried slip. The firing time/temperature was varied.

When comparing a self-coloured enamel with a conventional coloured enamel, i.e., one having a mill addition of a proprietary colouring compound, together with the usual clay and electrolyte addition, the selected proprietary colour was such that on firing at one temperature the colour was approximately equal to that obtaining with the self-coloured enamel.

To assess colour stability, comparable panels were fired at the same time for four minutes at three different temperatures, the resultant enamel colours measured photoelectrically, and also assessed visually.

Preliminary Assessment of Colouring Elements

The amounts of the various colouring metal oxides smelted into frit 2155 as indicated in Table II, are expressed as weight percentage on the calculated melted composition. All the panels in this series were fired for 4 minutes at 810°C .

A superior method of indicating colour is by means of a colour diagram (see Fig. 1).

Reproducibility of Chrome and Copper Tints

3×1 kilogram batches of frit 2155 containing 2 per cent copper oxide, and 2×1 kilogram batches containing 0.1 per cent chromic oxide were smelted, each on separate occasions.

All five frits were milled as usual and fired for 4 minutes at 810°C . The results are shown in Table III.

Thus the reproducibility of this type of coloured enamel is good.

Colour Stability to Firing Temperature Variations

The manganese, copper and chromium induced tints in frit 2155 were compared for colour stability with similar colours made by milling frit 2155 with proprietary colouring compounds with results as shown in Table IV and Fig. 1.

*Formerly of British Titan Products Co. Ltd.

TABLE I
Frit Formulae

Batch Compositions

2155		212		231	
Quartz	32.3	Felspar	26.5	Felspar	28.0
Borax (hydrated)	23.3	Borax (hydrated)	22.5	Borax (hydrated)	22.0
BTP. Titanium Oxide	15.1	Quartz	26.5	Quartz	25.0
Felspar	8.9	Sodium Nitrate	4.1	Sodium Carbonate	6.5
Potassium Nitrate	13.5	Cryolite	6.1	Sodium Nitrate	7.0
Cryolite	2.6	Zinc Oxide	4.1	Sodium silico-fluoride	3.0
Zinc Oxide	1.0	Barium Carbonate	1.0	BTP. Titanium Oxide	8.5
Magnesium Carbonate	0.7	BTP. Titanium Oxide	9.2		
Monammonium Phosphate	2.6				
	100.0		100.0		100.0

Calculated Melted Compositions

2155		212		231	
SiO ₂	47.5	SiO ₂	50.9	SiO ₂	53.6
TiO ₂	18.8	TiO ₂	10.6	TiO ₂	10.2
B ₂ O ₃	10.7	B ₂ O ₃	9.5	B ₂ O ₃	9.7
Al ₂ O ₃	3.0	Al ₂ O ₃	7.7	Al ₂ O ₃	6.5
P ₂ O ₅	1.9	Na ₂ O	10.1	Na ₂ O	14.4
Na ₂ O	6.4	K ₂ O	3.1	K ₂ O	3.4
K ₂ O	8.9	ZnO	4.7	F ₂	2.2
ZnO	1.2	BaO	0.9		
MgO	0.4	F ₂	2.5		
F ₂	1.2				
	100.0		100.0		100.0

It is thus apparent that the pink, turquoise and cream colours caused by a "smelted in" colouring agent are more stable to firing variations than the orthodox coloured enamels. This applies particularly to pink and turquoise.

Influence of Frit Ingredients on Colour

(a) Iron Oxide Additions

Frit 2155 was smelted with (i) 0.1 per cent Cr₂O₃, (ii) 5 per cent NiO, (iii) 1 per cent MnO₂, (iv) 2 per cent CuO, and also a second set with the same

TABLE II

Metal Oxide	Addition, per cent	Percentage Reflectance in				Colour Index	Visual Colour
		White	Red	Blue	Green		
Nil	—	77.0	75.5	78.0	78.0	— 3.2	White
Black cobalt oxide	0.5	53.5	48.0	67.0	56.5	—33.6	Pale Blue
do.	1.0	42.0	36.5	58.0	45.5	—47.4	Blue
Manganese di-oxide	1.0	58.0	65.0	45.5	53.0	+37.0	Flesh pink
do.	2.0	44.0	53.0	29.5	37.0	+63.5	Reddish brown
Copper oxide	1.0	70.5	65.0	73.5	75.5	—11.3	Duck-egg blue
Copper oxide	2.0	64.5	57.0	68.0	70.5	—15.6	Deeper duck-egg blue
do.	5.0	56.0	45.0	60.5	63.5	—24.5	Turquoise
Chromium oxide	0.1	68.0	75.5	43.0	64.0	+50.8	Deep cream
Nickel oxide	1.0	71.0	73.0	60.0	70.5	+18.5	Light stone
do.	2.0	68.5	71.0	49.0	69.0	+31.9	Lemon yellow
do.	5.0	66.0	69.5	38.5	66.5	+46.8	Pale canary yellow
Copper oxide	5.0						Poor gloss.
Chromium oxide	0.05	50.0	45.0	37.0	57.0	+14.0	Pea green

TABLE III

Oxide in frit.	Batch	Percentage Reflectance in				Colour Index
		White	Red	Blue	Green	
2 per cent CuO	1	64.5	57.0	68.0	71.0	-15.5
do.	2	64.5	56.5	67.5	71.0	-15.5
do.	3	64.5	57.0	68.0	71.0	-15.5
0.1 per cent Cr ₂ O ₃	1	70.5	75.5	49.0	69.5	+38.0
do.	2	71.0	76.0	50.5	70.5	+35.7

colouring oxides in the frit, together with an addition of 3 per cent ferric oxide on the TiO₂. These eight frits were milled as before, sprayed, then fired for 4 minutes at 810°C.

The results, as shown in Table V, indicate that the iron-oxide addition in all cases causes a shift to a yellower or less blue tone, which results in an apparently brighter and more opaque finish.

(b) Modification of Basic Frit Constituents

Twenty six batches of slightly modified frit 2155 + 2 per cent copper oxide were smelted, the modifications being an increase and decrease in each of the frit constituents. Each frit was milled with the usual clay and electrolyte addition and the sprayed panels fired 4 min. at 810°C.

From these variations the following can be deduced:—

Sodium. Increasing the Na₂O causes a marked decrease in blue tone with an increase in yellowness and brightness.

Potassium. K₂O increases cause a decrease in blue tone and an increase in yellowness and brightness.

Silicon. SiO₂ increase causes a darkening and intensification of the blue. This change is less than that which occurs with similar Na₂O decrements.

Titanium. Increasing the TiO₂ causes a slight intensification of blue tone.

Aluminium. Al₂O₃ has little effect on colour in the range investigated.

Zinc. In the range investigated ZnO variations have little effect on colour.

Fluorine. Increasing the F₂ content of the frit causes a marked increase in green or yellow tone. This fact should be remembered when considering the influence on colour of under- or over-smelting.

Phosphorus. In the range investigated the P₂O₅ variations have little effect on colour.

Boron. Increasing the B₂O₃ causes a general brightening of the fired enamel, while a B₂O₃ decrease induces a greenish tone.

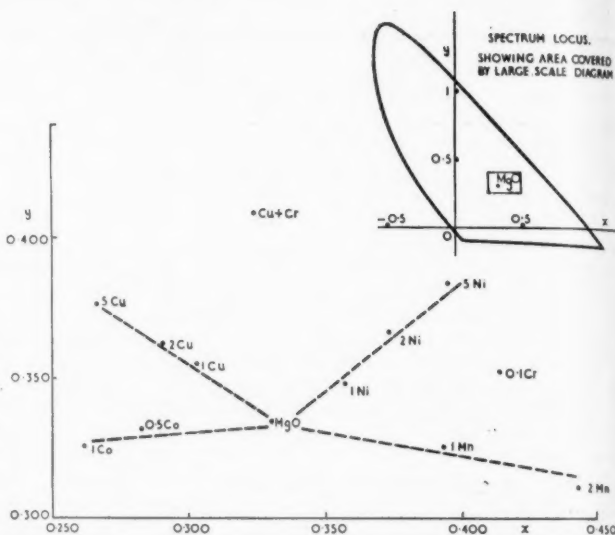
Influence of Colouring Ions on Other Titania-bearing Frits

When compounds of the usual colouring elements were smelted into the rutile-opacified frit 212, similar colours were obtained (on firing) to those obtained with the frit 2155 series previously

TABLE IV

Oxide in frit. per cent	Colour at Mill	Fired 4 min. at °C.	Percentage Reflectance in				Colour Index
			White	Red	Blue	Green	
Nil	Nil	780	75.5	74.0	78.5	78.0	- 5.8
Nil	Nil	810	78.0	77.5	79.5	80.5	- 2.4
Nil	Nil	840	78.5	78.5	77.5	80.5	+ 1.2
1 MnO ₂	Nil	780	61.0	65.5	53.0	59.0	+21.2
do.	Nil	810	62.0	67.0	52.5	60.0	+24.2
do.	Nil	840	63.0	68.0	51.5	61.0	+27.0
Nil	Red Oxide	780	64.5	69.0	57.0	62.0	+19.3
Nil	do.	810	66.5	71.5	57.5	66.0	+21.2
Nil	do.	840	68.0	73.0	57.0	67.5	+23.7
2 CuO	Nil	780	63.0	55.5	68.0	72.5	-17.2
do.	Nil	810	65.0	58.0	69.5	74.0	-15.5
do.	Nil	840	66.0	59.5	70.0	75.0	-14.0
Nil	Blue oxide	780	66.5	62.0	75.5	72.5	-18.6
Nil	do.	810	68.5	65.5	74.5	75.0	-12.0
Nil	do.	840	68.5	66.5	67.5	74.0	- 1.3
0.1 Cr ₂ O ₃	Nil	780	66.0	71.5	44.0	63.0	+43.7
do.	Nil	810	68.0	75.0	44.5	64.0	+48.0
do.	Nil	840	68.0	75.5	42.0	63.5	+53.0
Nil	Cream oxide	780	64.0	69.0	43.0	61.5	+42.2
Nil	do.	810	66.0	71.5	44.5	63.5	+42.6
Nil	do.	840	67.5	74.0	41.0	64.0	+51.5

Fig. 1.—Colour Diagram.



described. One difference observed, however, was that when 5 per cent nickel oxide in frit 212 was fired, a good glossy enamel was obtained, whereas in frit 2155 a semi-matt and apparently under-fired enamel resulted.

With the clear frit 231 it is also possible to obtain good colours by the "smelting in" technique, but a mill addition of at least 2 per cent titania is necessary to obtain adequate opacity. This applies particularly to the 0.1 per cent Cr_2O_3 and 0.5 per cent CoO containing frits. With the 5 per cent nickel-oxide frit a matt enamel resulted.

Role of Colouring Element in a Fired Enamel

The colours of the frits containing "smelted in" oxides are what one would expect from the particular ions incorporated, bearing in mind the effect of the intrinsic brown colour of the basic frit.

On firing, however, it is possible that either the colour remained in the glass unchanged, and the recrystallizing TiO_2 served to lighten the colour and render the enamel opaque, or the recrystallized titania combined with the colouring ion to form a titanate or titanium-colouring element complex, differing in colour from that of the frit. A third phenomena, in which the colouring element itself recrystallized, is described later.

The dual role of a colouring ion is best illustrated by considering a titanium frit containing cobalt. In all cases the frit had the usual cobalt blue colour, but on firing, a light blue or a green was obtained, depending upon frit composition, the amount of cobalt present, and the firing temperature.

Examination of Table VI reveals that higher firing temperatures favour the blue associated with cobalt-blue glasses, lightened by the recrystallized titania, whereas at lower temperatures a cobalt green is formed. Higher cobalt contents naturally favour the formation of the titanate.

That the green is due to titanate formation, and the blue due to a cobalt silicate complex was proved by X-ray examination of frit 2155 + 1 per cent cobalt oxide fired at 810°C . and frit 212 + 4 per cent cobalt oxide fired at 810°C .

TABLE V

Oxides in the frit (per cent of melted composition)	Percentage Reflectance in				Colour Index	Visual Colour
	White	Red	Blue	Green		
0.1 Cr_2O_3	68.5	74.0	47.0	67.5	+40.0	Deep cream, sl. grey tone
0.1 Cr_2O_3 +	72.5	77.5	50.5	71.5	+39.2	Bright, deep cream
0.5 Fe_2O_3 }	69.0	72.5	45.5	72.5	+37.0	Pale canary yellow
5.0 NiO	67.0	69.0	41.5	69.0	+39.8	Sl. deeper canary yellow
5.0 NiO +	62.0	66.0	50.0	59.5	+26.4	Pink
0.5 Fe_2O_3 }	67.5	68.5	54.0	62.5	+23.2	Brighter pink
2 CuO	68.0	61.0	70.5	75.0	+13.0	Pale turquoise
2 CuO +	68.5	62.0	70.0	75.0	+10.7	Pale turquoise. Sl. less blue
0.5 Fe_2O_3 }						

TABLE VI

Frit	Cobalt Oxide, per cent	Fired 4 min. at °C.	Visual Appearance
212	0.5	810	Pale blue—turquoise
212	2	810	Green bice
212	2	860	Greenish eau-de-nil
212	4	810	Deep Brunswick green
212	7	810	Traffic green
2155	3	765	Brunswick green
2155	3	810	Blue—sl. mauve
2155	5	765	Very deep green—almost matt
2155	5	810	Blue—slight green cast
2155	5	860	Blue
2155	7	765	Very deep green—almost matt
2155	7	770	Middle Brunswick green
2155	7	800	Deep turquoise
2155	7	830	Turquoise
2155	7	860	Blue turquoise

Electron microscope photographs were also taken of the crystalline phase present in these two enamels, using the HF extraction technique.

X-Ray Examination

- 2155 + 1 per cent CoO (blue colour)
70 per cent rutile 30 per cent anatase—no other phase
- 212 + 3 per cent CoO (green colour)
Cobalt titanate + large amount of a second phase, which is not TiO₂.

Electron Micrographs

- 2155 + 1 per cent CoO (blue colour)
Mixed anatase and rutile crystals.
- 212 + 3 per cent CoO (green colour)
Crystals of cobalt titanate + irregular masses + few rutile needles.

The rutile crystals observed in the electron microscope photographs of the green enamel are present in too small a concentration to be detected by X-ray examination.

After the hydrofluoric-acid treatment of the blue and green panels, the colour of the liberated powder was interesting—that from the blue enamel was white, while that from the green enamel was green.

That the green colour was due to the cobalt titanate and not to the second unknown phase was shown by preparing cobalt titanate pigment. This may be made by calcining together black cobalt oxide and titania, whereupon a strong green-coloured pigment results. According to B.P.413,915, the cobalt titanate may be green or blue, higher temperature favouring the blue form. This blue, however, has a tone different from that obtained from the blue enamels previously described.

A second example of the dual role of colouring ion in a titanium enamel is seen in the case of chromium. The frit containing 0.1 per cent Cr₂O₃ is green, but after firing, the well known chrome/titanium cream colour results. When green chromium oxide is added as a mill addition to a titanium self-opacified enamel, and fired, a pale blue green colour is produced. Under these conditions, the cream chrome/titanium colour is not developed and the colour of the enamel is stable to variations in firing time/temperature. This is probably due to the very refractory nature of chromic oxide.

Investigation into Metallic Lustres formed by Recrystallization

When frit 212 containing 5 per cent copper oxide was fired at low temperatures, a metallic lustre was produced which covered the whole surface of the fired enamel.

This phenomenon was further investigated by smelting frit 212 with substantial amounts of copper, manganese, iron, nickel and cobalt oxides. Slips were milled and sprayed in the usual way, and the panels fired at various temperatures. The surface of the fired enamels was scratched to determine whether the lustre was a surface phenomenon, or whether it extended throughout the thickness of the enamel. Selected panels were subjected to a spot acid-resistance test and their corrosion resistance compared with the lustre induced by ferric chloride sprayed onto a standard panel of frit 212.

Results

- Using 5 or 7 per cent copper oxide, a coppery metallic lustre forms on firing at low temperatures, but is often marred by areas of the usual turquoise

(Continued in page 488)

Colour Stability of Enamels

(Continued from page 487)

colour associated with this colouring element. This lustre is a surface effect.

2. 7 per cent manganese dioxide in the frit causes a brown metallic lustre which appears to exist throughout the enamel.

3. On firing frit 212 containing 5 per cent iron oxide at low temperatures, a dark grey colour is formed which does not have a "lustre" effect.

4. With both 5 per cent nickel oxide and 7 per cent cobalt oxide no lustre is obtained and at low temperatures of firing a dark green colour is formed, and there is a progressive decrease in gloss with decrease in temperature.

5. When subjected to a spot acid-resisting test, all these finishes are less acid-resistant than the standard lustre obtained by the ferric-chloride-spray technique over normal 212 fired panels.

General Conclusions

1. Bright, clean, pastel shades may be obtained by smelting the oxides of various colouring elements into the frit of a titanium self-opacified enamel.

2. Chromium, cobalt, manganese, copper and nickel are effective, although the use of nickel is not recommended because of poor colour stability and deleterious effect on gloss.

3. The colour stability of this type of coloured enamel is superior to that of orthodox enamels in which colouring oxide is added at the mill.

4. Whether the colouring element retains its integrity in the glass, or reacts with the titania on firing, depends upon the amount and type of colouring element used, the frit formulation, and the firing time/temperature.

5. Cobalt-containing frits fire out to give either a blue or a green enamel.

6. Green chromic oxide may be used as a mill addition to form quite stable pale turquoise enamels.

7. The reproducibility of these self-induced coloured enamels is good.

8. Under certain conditions, it is possible to obtain a lustre finish by the incorporation of substantial amounts of copper or manganese oxides in the frit. The copper lustre is a surface effect, while the manganese lustre is distributed throughout the enamel. The copper lustre is difficult to reproduce, and all these lustres have inferior acid-resistance compared with that of the lustre finishes produced by ferric-chloride spray.

Grateful acknowledgement is made by the author to the Directors of British Titan Products Co. Ltd. and Radiation Ltd. for permission to publish this paper.

Screen Printing in the Ceramic Industry

(Continued from page 479)

steel printing cloths gave a much thicker deposit than silk was that it was impossible fully to anneal the stainless steel wire before the cloth was woven, and in the weave the strands, instead of being fairly flat as they crossed over, were rather unusually crimped. That crimp was the main reason why stainless-steel screens gave a very thick deposit. The double-knotted type of silk weave gave a thicker impression than the single-knotted type, owing to the difference in thickness and crimp of the material, but the mesh size had no influence.

The CHAIRMAN (Mr. W. Thomas), asked whether the author had experienced a difficulty due to the greater part of the area of the steel mesh being perfectly taut but a slackening being present at one small point; if this happened to be where there was small print the impression disappeared.

Mr. KERRIDGE suggested that the trouble might be due to defective weaving. The weaving of stainless-steel cloth was a very difficult process, and it was only in the last two or three years that good cloth had been woven. There was very often a join-up somewhere in the weave where the wire had broken, and there would be a weak point in the cloth owing to that cause. Another possibility was that there was some slight slippage of the metal cloth because it was not firmly gripped by the sides of the screen.

Dustblasting for High Quality Chromium Plate

(Continued from page 481)

tained three to five per cent of the large mesh sand.

As a result of the screen analysis, Ryan switched from the dust to 100-800 fine garnet sand and thereby cut the man-hours required for the hand-sanding operation by more than 30 per cent. The problem of using this extremely fine sand in the blasting booths, along with the more frequently used 36-mesh sand, was readily solved by an especially designed portable hopper. Equipped with hose attachments, the hopper can be wheeled into any of the booths, hooked up to the air supply and placed in use in a matter of moments. It can hold 300 lb. of the 100-800 sand.

Since the time Ryan began its own chromium plating operation, the quality of the plating has shown a marked improvement while the cost of the plating operation itself has been lowered—due mainly to the fact that time of plating has been cut from 14 to 8 hours. In addition, damage to the expensive motors, which occurred during shipment from plant to subcontractor and back again, has been eliminated.

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The Performance of BARE AND PAINTED ALUMINIUM ALLOYS

IN order to examine the suitability of aluminium alloys for service in the atmosphere of a chemical factory with a view to their use as structural members and for roofing sheet, a number of exposure tests have been carried out at four sites with various aluminium alloys, both bare and painted, and a small number of bare and painted mild steel specimens for comparison.

Details of these tests and the findings therefrom are given in a paper* by W. D. Clark, published by the Institute of Metals.

The following conclusions have been drawn from the evidence presented in the paper.

(1) Aluminium and many of its alloys are much more resistant to corrosion under the test conditions described than is mild steel, and on aluminium alloys paint has a longer life than on steel. While the capital cost of aluminium is greater, the reduced cost of painting may in some cases make its use economic. The longer life of aluminium may also render it a practical proposition in places where mild steel is so badly attacked that, for example, austenitic steel might otherwise have to be used.

(2) Bare aluminium alloys, even when used as thin sheet, have a considerable life even in contaminated atmospheres, but under severe conditions it is probably economic to paint them. Thick (e.g. over $\frac{1}{4}$ in.) structural members will naturally lose strength less quickly when bare than thin sheet, but when a long life—over 20 years—is required, it would seem desirable to paint them unless experience has proved this to be unnecessary.

(3) Very little difference has been found between 99.5 per cent aluminium, aluminium-magnesium alloys and the magnesium-silicide type of alloy. The last (H10-WP) has, however, a slight tendency towards intercrystalline attack, and in circumstances where safety is of paramount importance and corrosive conditions severe, it would seem better to avoid its use.

The high-strength 4 per cent copper alloy (H15-WP) is much inferior and suffers severe intercrystalline attack, as has several times previously been reported.

(4) It is noteworthy that cold rolling does not reduce the corrosion-resistance of NS7 or its performance as a base for paint.

(5) Paint coatings have a much longer life on

in Corrosive Atmospheres

aluminium alloys than on steel. The alloy used as base has little effect on the life of the paint except in the case of H15-WP, on which paint fails more quickly and more severely than on the other alloys tested. The behaviour of the magnesium-silicide alloy is slightly worse than that of the aluminium-magnesium alloys.

(6) Pretreatment of the surface markedly improves the performance of paint on aluminium. Differences found between various chromate dipping processes and anodizing are not significant.

(7) Zinc chromate in linseed oil is a good primer; the others tested are less good. The vehicle for zinc chromate is not apparently very important. Other investigators have reported red lead primer to be significantly deleterious, and no evidence on this point has been sought.

(8) Variations in the cover coat(s), from a single coat of tar paint to a two-coat alkyd cover, produce only minor variations in deterioration after 31 months' exposure. It would seem that any properly compounded paint can be used with good prospects of at least four years' life before repainting, even in bad conditions.

(9) When painted specimens which have failed locally are cleaned in the same way as for mild steel, spot-primed, and repainted locally, there is no evidence that salts occluded in pits and intergranular crevices lead to rapid shedding of the renewed paint.

(10) Under many conditions the under side of aluminium sheets or members is liable to much more severe attack than the upper surface. This will probably apply in most cases where the atmosphere on the under side is the same as that in contact with the upper surface.

(11) Contact tests between various materials used as washers and the upper surface of bare aluminium specimens have shown only brass to be strongly detrimental. Galvanized mild steel causes the least trouble of the materials tested, but several other materials are little worse. The galvanized nut, bolt, and washer are, however, very heavily attacked and consideration should be given to the use of more resistant materials for securing roof sheets. Aluminium alloy bolts, chromized mild steel, or mild steel protected with a thick coat of plasticized polyvinyl chloride would appear to deserve consideration.

*Atmospheric Corrosion of Aluminium Alloys in a Large Chemical Factory and their Protection by Painting. By W. D. Clark, M.A., M.Sc., A.I.M.

FINISHING POST

A SELECTION OF
READERS' VIEWS COM-
MENTS AND QUERIES ON
METAL FINISHING
SUBJECTS

Advice on all aspects of metal finishing practice is offered on these pages, and while every care is taken to ensure the accuracy of information supplied no responsibility can be accepted for any loss which may arise in respect of any errors or omissions.

Stripping Anodic Coatings

1012. We have acquired a number of small pressed components in commercially pure aluminium from which we want to remove the unsightly dyed anodized coating. Can you please inform us of a simple and economic way of doing this?

The film can be stripped quite easily in a solution of caustic soda but this solution has the disadvantage that it will attack the aluminium. If it is required to remove the film without attacking the metal, a solution of 30 gm per litre of phosphoric acid and 25 gm per litre of chromic acid should be used. This may be used warm and although rather slower in action will strip the film quantitatively with practically no attack on the underlying aluminium.

Vat Linings

1013. We would welcome your guidance in connexion with some new equipment we are proposing to install in our plating shop. We are going over to a bright nickel solution which contains an organic brightening agent and would appreciate some information on which to base our final selection of vat-lining material.

The majority of bright nickel solutions in present use are contained in rubber-lined steel vats. It is, however, essential that the rubber lining should be done by a firm who are experienced in this type of work and whose rubber has been shown not to contaminate the solution. Many samples of rubber contain accelerators which slowly leach out of the lining and will affect the working of a bright nickel solution and, in fact, in certain cases an ordinary nickel solution as well. If it is proposed to have the vat rubber lined directly by one of the rubber firms, it is advisable either to obtain a sample of the rubber they propose to use and test it in conjunction with the solution for which it is required, or in the case of a proprietary bright nickel solution, to submit it to the proprietors of the solution and ask them to check it.

Polythene may be used instead of rubber, particularly on smaller tanks but it cannot be bonded directly to the steel and trouble may be experienced due to the polythene, which has a different co-efficient of expansion from that of the steel, splitting at the joints. Also some samples of

polythene contain plasticizers and other materials which are attacked by the wetting agents in some of the bright nickel solutions. This difficulty has been overcome in certain instances by having a double polythene layer of which the inner one only is plasticized. On the whole, therefore, polythene can only be recommended, if the lining of a tank is carried out by a reliable firm and if the tank is not a particularly large one.

Glass-fibre reinforced polyester tanks and solid P.V.C. tanks are being tried out but there is not, at the moment, sufficient experience available to warrant an unqualified recommendation for them and the best-tried material is undoubtedly a rubber lining of the correct composition at the present time.

Nodules on Nickel

1015. We are having considerable trouble with small nodules on a bright nickel deposit. These nodules appear to be quite sharp and are spread at random over the work, at times disappearing for several days and then again reappearing. We would be glad to know if the cause of this defect has been established and whether anything can be done to avoid it.

The type of nodule described is usually brought about by a small conducting particle in the solution. This particle may be graphite or a very finely divided particle of nickel and usually comes from the anodes.

It would be advisable to examine the anodes carefully to see whether there is a black scum on them and also to see if the anode bags are free from holes, etc. It is possible for these very small particles to go through a normal anode bag.

The solution should be carefully filtered and the tank cleaned out. If depolarized anodes are being used it should be remembered that these anodes do not work too well at a low current density and if there is a number of anodes in the tank and not much current passing through it, it would be advisable to remove some of the anodes so that the current density on those remaining is of the order of 10 amp per sq. ft.

The filtration plant should be checked to see that it is working satisfactorily and the solution should be kept filtered; this should remove the cause of the trouble.

(Continued in page 492)

Finishing Post*(Continued from page 491)*

cyanide solution of the normal composition, but have been unable to obtain satisfactory results. In many cases the articles (small screws) refuse to cover. We are at a loss to understand this as the solution appears to work satisfactorily in some other barrels we are using for zinc plating.

It is probable that the trouble is due to the fact that the barrel is turning too fast. It is possible to barrel screws with cadmium at some 5-10 r.p.m. quite satisfactorily, but it is normally found that when using zinc the barrel requires to be slowed down to about 3 r.p.m. We would suggest slowing the barrel. If you still get difficulty in covering steel screws the addition of about $\frac{1}{4}$ th of an ounce of sodium stannate to the solution will probably assist. Alternatively, work which is difficult to cover with zinc may be given a tin-immersion dip before being placed in the barrel.

Gold Finish on Steel

1017. We wish to obtain a cheap imitation gold finish on some steel parts for ornamental purposes only and would be glad if you could advise us if there is a satisfactory method of doing this.

One method sometimes adopted for this purpose is to plate the steel parts with bright nickel and then to flash them in a brass solution. The brass solution can be adjusted to give the desired colour, after which the parts are dried off and lacquered with a slightly tinted lacquer to produce the final colour required.

Nickel Plating of Brass

1018. We understand that it is a widespread practice to copper-plate brass parts before depositing bright nickel but we are at a loss to understand the reason for this. It appears to us that it should be satisfactory and cheaper to nickel-plate these parts directly. Is there, in fact, any technical reason why brass should be plated with copper before nickel?

The ordinary 70/30 brass can be plated with bright nickel quite satisfactorily but many brasses used in industry, particularly those required for machining, contain up to 2 per cent of lead. Such a brass is difficult to plate direct with bright nickel and in many cases the brightness may be affected. To overcome this difficulty the parts are first copper plated in a cyanide copper bath.

Many jobbing platers have to deal with a large variety of brass articles of which they do not know the composition. They may therefore find it preferable to copper-flash all their brass work rather than go to the trouble of finding out whether the brass is a lead bearing one.

2nd International Enamelling Congress*(Continued from page 468)*

was devoted to the final technical session, and in the evening the Congress was the guest of the president and Lady Briggs at a reception.

The technical programme having been concluded, the Congress venue then moved north to Manchester, where some forty overseas delegates attended a reception staged by the Northern section before embarking on a conducted tour of works in the North of England and in Scotland. The works visited included John Summers and Sons Ltd., The Richmond Gas Stove Co. Ltd., The English Electric Co. Ltd., Stoves Ltd., The Carron Company, M. Cockburn and Co. Ltd. Smith and Wellstood Ltd., and Mitchell Russell and Co. Ltd.

For the visits in Scotland the Congress was centred on Edinburgh, where delegates were accorded a civic reception by the Lord Provost and the City Corporation. The Congress was finally terminated by a dinner at the George Hotel, Edinburgh.

Since the end of the Congress many cordial expressions of good will and appreciation of the hospitality accorded to them during their stay in this country have been received from overseas delegates, and there can be no doubt that in staging this Congress the Institute of Vitreous Enamellers has done much to foster the already good relationships which have existed between it and its kindred bodies and the enamelling industries in other parts of the world.

Maintenance and Repair of Machinery of the Fleet*(Continued from page 482)*

development of weld deposition to restore worn and corroded propeller shafting up to the largest sizes, and considerable skill has been achieved in avoiding distortion of the shaft and cracking of the deposited metal. Many other items are built up by this process and the now common practice of applying an ultra-hard facing to valve seats is employed. Argon-arc, and carbon-arc welding is used for building up non-ferrous materials. A further method of reclamation used is that of freezing in new parts. This is particularly applicable to submarine-engine aluminium pistons in which a fully floating gudgeon-pin works in bosses cast in the piston. Pistons worn at this position are treated by boring out the bosses and freezing in new aluminium bushes of the same alloy.

Lack of success in passing examinations arises almost as frequently from failure to apply knowledge properly as from failure to acquire knowledge. This series of articles is intended to assist actual and intending entrants for the City and Guilds Certificate Examinations in Metal Finishing to answer examination questions in the most effective manner.

A Students Guide to Examination Courses in Metal Finishing

II. INTERMEDIATE (Cont.)

Compiled by **A. ALEXANDER**

(Series continued from page 368, August, 1955)

General

PART 2 of the syllabus covers the more practical part of the Course. For this part the candidate is required to know the theory of action of a copper-sulphate and a copper-cyanide solution, and also to have a general knowledge of other electroplating practice, including plant, methods of polishing, methods of preparation and the processes employed for depositing the commoner metals. However, at the Intermediate stage no detailed knowledge of these latter processes is expected, it being sufficient if a candidate can give a general description of the processes and have some idea of the purpose for which it is used.

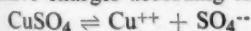
Deposition of Copper

It is intended that this process shall be dealt with at some length. Two types of solution are used, an acid copper-sulphate solution, which is generally used for building up thick deposits of copper, and also for depositing copper on certain non-ferrous metals, and a cyanide solution which is used for plating steel and zinc. While there are now several other types of solution, in general use, these do not come under the Intermediate syllabus and need not be considered at this time.

Acid Copper Solution

The acid copper solution is generally considered to be one of the simplest from the point of view of its operation and control. It consists of a solution of copper sulphate, the usual concentration being some 200 gm. per litre of crystalline copper sulphate, together with about 50 gm. per litre of sulphuric acid. The exact concentration of the constituents is not particularly important, and for some purposes the concentration of the acid is varied, but the above formula is typical.

When copper sulphate is dissolved in water, it ionizes to produce a cupric ion carrying two positive charges, and a sulphate ion carrying two negative charges according to the equation:—



Under the influence of an applied potential the copper ion migrates to the cathode, where the charge is neutralized and it becomes a copper atom. The sulphate ion migrates to the anode, which is normally a piece of copper, and there dissolves off an equivalent of copper to give copper sulphate. Since copper is deposited in preference to hydrogen, no gas is normally liberated at the cathode, and the sulphuric acid present in the solution serves only to assist in carrying this current and make certain that basic salts are not formed on the surface of the cathode, which, as previously mentioned, is always somewhat more alkaline than the bulk of the solution. The theory of this solution should be clearly understood. There is some evidence to show that it is not perhaps quite as simple as may appear in the above statement, but if the Intermediate candidate can state the theory in its simplest form this is all that is required.

It is necessary for a candidate to be familiar with the results of varying the physical conditions of deposition, that is to say, varying the current density, temperature and agitation of the solution.

Current Density

The current density governs the speed at which the copper is deposited. If the current, through the depositing cell is gradually increased, it will be apparent from Faraday's Law that the speed at which the copper is deposited will be increased in proportion. This action will take place until a certain limiting current density is reached. If the current is still further increased, it will be found impossible to bring up the copper ions to the cathode surface sufficiently quickly to carry it. The cathode potential will then rise sharply and will soon reach a value at which it is possible for hydrogen ions also present in the solution to be discharged. Hydrogen will then be liberated at the cathode surface and while a certain amount of copper will continue to be deposited, this copper will deposit in the form of a rough powder, instead of a coherent crystalline mass. In the trade, this type of deposit is known as a "burnt"

deposit, although, of course, there is no actual heat involved.

If it is required to speed up the process, therefore, it is necessary to arrange conditions of deposition so that the copper ions can migrate to the cathode surface as quickly as possible. As mentioned in Part I, the movement of these ions is partly due to their migration under the potential difference existing in the solution, partly due to the ordinary diffusion of a substance in solution, and partly due to the movement of the solution itself. Even in an unagitated cell a certain amount of movement will take place, because at the cathode surface metal ions are being discharged from the solution and it therefore becomes lighter and rises, while at the anode surface, metal becomes dissolved into the solution which becomes heavier and sinks.

If the temperature of the solution is raised its viscosity is reduced and the ions are able to diffuse far more quickly. Under these circumstances it is possible to use a higher current density before a point is reached at which an unsightly deposit is produced. If, in addition the solution is agitated or alternately, the cathode surface is moved so that it comes in contact with fresh solution, then again the current density can be increased.

It is important that the relation between temperature, current density and agitation of the solution, or cathode movement, should be fully understood. This relation applies generally through the majority of deposition and other electrolytic processes, and the candidate should be able to give a clear description in his own words of the relative effect of these three factors. These will again be stated:—

Increasing current density will increase the speed of deposit, but ultimately may cause unsatisfactory deposits;

Increasing temperature will make no difference to the speed at which the metal is deposited at a given current density, but will allow a higher current density to be used;

Agitation will also allow the use of a higher current density and, in general, gives a very similar result to increasing temperature.

At very low current densities the number of copper ions being discharged on a given area of the cathode is relatively small. These will normally, therefore, find little difficulty in being able to take up their position in the lattice structure of the crystals already present on the cathode surface, and therefore the deposit formed at such current densities will consist of relatively large crystals. If the current density is raised, the copper ions will be liberated very much more quickly, and under such circumstances may have more difficulty in entering the existing crystal lattice and will tend, in many cases, to start new crystals.

Thus the structure will consist of a smaller crystal and the metal will be somewhat harder. Increasing current density, therefore, without increasing temperature or agitation, will tend to produce a deposit with a finer structure and a somewhat greater hardness.

While this general type of effect is standard for most plating solutions, in point of fact the change in hardness with current density, particularly in an acid copper solution, is not very great, and other factors often produce a much greater change.

Concentration of Metal and Hydrogen Ions

It is obvious from what has been said, that the higher the concentration of the copper ions present in the solution, the higher the current density that can be used. In point of fact, however, moderate changes of concentration do not make a very great difference in practice. It is not possible greatly to increase the concentration of the copper sulphate present in the normal solution, because if this is done the solution will tend to crystallize out at room temperature and will require continuously to be kept warm. If, however, the concentration of the copper becomes depleted, then the speed at which the solution can be worked to give a satisfactory deposit will be reduced.

If the concentration of the sulphuric acid is reduced materially the resistance of the solution will be increased and it will be, therefore, necessary to use a higher voltage across the cell to maintain the current. Also there is a danger that the anode will not dissolve sufficiently quickly to maintain the action. If the anode does not dissolve satisfactorily, or if the reaction products cannot be quickly removed from the anode, surface, the anodes will become passive and instead of dissolving in the solution, oxygen will be liberated at their surface which will become covered with a thin film of oxide. This will also happen if the temperature is too low. In such a case it becomes practically impossible to get any current through the cell at all. It is necessary, therefore, to maintain a certain excess of sulphuric acid in the solution both to maintain the anode action and the conductance of the solution.

Effect of Impurities

So far it has been assumed that there was nothing present in the solution except copper sulphate and sulphuric acid and, of course, water. This is an ideal case which can, however, never be realized in practice and even the most carefully prepared solution will certainly contain small quantities of various impurities.

It is very essential that those dealing with electrodeposition processes should understand thoroughly the effect liable to be produced by small

quantities of various impurities in a plating solution, particularly as this effect is very often much greater in magnitude than the type of effect which has been under discussion. It has often happened both in experimental work and in production, that people have been misled by the results that they have obtained because they have neglected the effect of impurities present and have ascribed results due to these impurities to other circumstances.

In the case of a copper-sulphate solution the effects of metallic impurities for the most part are by no means so noticeable as for many other types of solution because copper is liberated at the cathode before most other metals and therefore, even if a certain amount of iron, zinc, nickel, etc., is present, these metals will not be liberated at the cathode surface and will, therefore, not alter the nature of the deposit produced. However, under certain circumstances, if the cathode potential rises sufficiently due to the depletion of the copper ions in the cathode layer, and some of these metallic impurities reach a limiting concentration, then they may become deposited and may effect the deposit. In normal copper deposition processes this is, however, unusual.

On the other hand, quite small amounts of certain organic materials may enter the solution from various causes. These materials are often present in the solution in the form of a colloid, that is to say, a molecule carrying a small charge and remaining suspended in the solution. These colloidal particles may, in certain circumstances, be carried to the cathode layer and become deposited on to the surface. These particles are, of course, relatively large, sometimes many hundred times larger than the metal ion, and their adsorption on to the surface may, and usually does, cause very considerable disturbances to the growing crystal lattice. This action is not, at the moment thoroughly understood, and there is still a certain amount of doubt as to its exact mechanism, but in fact it has been found that many such substances do produce a very great modification in the structure of the metal deposited, in general producing a hard and more highly stressed deposit. It is sufficient that an Intermediate candidate should know that colloidal matter of this type, for example, such substances as glue or gelatine, if present in a copper solution will produce a very marked change in the structure of the deposit. Small quantities may produce a hard shiny deposit of good mechanical properties, whereas large quantities will produce a brittle unsatisfactory deposit. The quantities present may, actually be exceedingly small, for example, one part of gelatine in one hundred thousand parts of solution by weight, will produce a very marked effect on the structure. Since it is actually

impossible to detect such small quantities of organic matter analytically, it is often extremely difficult to find out whether the observed effects in certain deposition processes are due to contamination by small quantities of organic matter or to other causes. Not all organic materials effect solutions in this way, some being relatively harmless, but at the present moment it is not possible to predict on a theoretical basis alone whether the material *will* produce an effect and whether such an effect will be harmful or otherwise. However, as mentioned, it is sufficient that the Intermediate candidate should realize the type of effect that may be produced and have a general idea of the method by which it is produced, and no detailed knowledge of the effect of specific materials is expected at this stage.

Uses of Acid Copper Solution

An acid copper solution is normally used for building up heavy deposits of copper, because it is possible, by working the solution warm and by agitating it, to deposit copper at a high rate. Current densities of 50 to 100 amp. per sq. ft., can quite easily be obtained at temperatures of about 120°F. and very much higher current densities have been employed on certain specialized processes. Thus the solution is generally used for growing electrotypes for printing, photogravure rollers, gramophone record stampers, reproduction of artistic objects and a number of other similar purposes. It is also used for plating brass objects prior to colouring and for a number of other special plating processes.

However, it cannot be used to deposit copper directly on steel or zinc or on metal which, if dipped into the solution, will form a deposit of copper by immersion. Since copper tends to deposit out in preference to iron, if a piece of steel is placed in an acid copper solution, the iron will go into the solution and the copper will be deposited on the surface. From an ordinary copper-sulphate solution this copper will deposit out on the surface as a non-coherent powdery layer, and if an attempt is made to plate the copper on to the steel from this solution, this immersion layer will prevent the adhesion of the deposit. In order to overcome this trouble, it is necessary to use a solution which will not produce this effect.

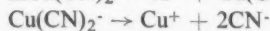
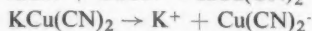
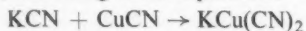
Copper-cyanide Solution

In order to prevent the copper depositing out, by immersion, on to the surface of the metal to be plated, it is necessary to use a solution in which the concentration of the copper ions present at the surface is extremely small. If instead of using an acid copper-sulphate solution, a solution produced by dissolving cuprous cyanide in potassium or

sodium cyanide is used, then it will be found that since in such a case a double cyanide is formed, extremely few copper ions are produced, and that the concentration of these is not sufficient to form the loose powdery type of deposit produced in acid solutions of a simple copper salt. Under these circumstances it is possible to obtain a satisfactory adherent deposit on such metals as steel and zinc.

The standard copper-cyanide solution is composed of a double salt of an alkaline metal cyanide, and copper cyanide. It requires a certain amount of additional alkali cyanide in order to keep the copper in solution, and also to assist the solution of the anode, and other substances, such as Rochelle salt, copper sulphite, etc., are often added for various purposes. A normal type of copper solution would contain 5.8 oz. of potassium cyanide and 4 oz. of copper cyanide per gal. In addition, $\frac{1}{2}$ oz. per gal. of sodium bisulphate and 1 oz. per gal. of sodium bicarbonate, could be added. Such a solution is typical of those in use, although their composition may vary somewhat.

As mentioned in Part I, there has been some considerable controversy over the exact method by which copper is deposited from such a solution. It has been suggested that the double-cyanide ions produce a potassium ion only and that this potassium ion reacts chemically with the double cyanide at the cathode layer to produce copper by a purely chemical action. This theory, which at one time was favoured, now generally has given place to the idea that a cuprous ion is formed by a secondary ionization of the cupro-cyanide complex, according to the equations:—



It is considered that this secondary ionization takes place to a very small extent and thus the concentration of the cuprous ions present is very low, but as these are deposited out they are immediately replaced by a further quantity due to the complex ionizing. Again the exact mechanism of this is somewhat complicated, but if the Intermediate candidate is familiar with the general idea of the double ionization, and can state this theory as being that at present preferred, this is all that will be required at this stage.

In the cyanide solution the copper is present as a cuprous ion carrying only one positive charge, and therefore a given quantity of current should deposit twice as much copper as it would do if passed through the acid copper solution. However, the current efficiency of a cyanide solution is not as high as an acid solution, because a certain amount of hydrogen will also be liberated at the cathode. Also, since the solution does not conduct

so well as the acid solution more work has to be done to deposit the copper from it, so the overall tank voltage will be higher and actually more power is required to produce a given thickness of copper from a cyanide solution than from an acid solution.

Although the cyanide solution is definitely alkaline there will still be a number of hydrogen ions present; this is because water itself ionizes slightly, so that in pure water there are present a small concentration both of hydrogen ions and hydroxyl (OH^-) ions. In a neutral solution a concentration of these two ions will exactly balance, as the solution becomes alkaline the concentration of the hydroxyl ions will increase and that of the hydrogen ions decrease, but although in alkaline copper solution the hydrogen-ion concentration will be extremely small, there will still be a number of these ions present and thus the hydrogen will still be liberated at the cathode surface. In general, the effect of current density, temperature, agitation, etc., will be the same as in an acid copper solution; for most purposes, however, agitation is not used partly because due to the poisonous nature of a cyanide solution an agitated solution of this type is rather unpleasant to work unless it is carefully exhausted, and partly because for the majority of purposes for which this solution is used it is not required. Cyanide solutions, however, are used at times for building-up heavy deposits and under these circumstances they may be agitated either by moving the article on which the deposit is being made or by the use of compressed air or other suitable means. For the most part they are worked warm, about 90 to 110°F., but it is usual to avoid working them at too high a temperature because under such conditions the cyanide tends to break down quickly.

In operating a copper-cyanide solution it is, of course, necessary to control the temperature, current density and composition. At 110°F. the solution will operate satisfactorily between 5 and 10 amp. per sq. ft. with current efficiency of about 60 per cent. The anodes are normally rolled or extruded copper and the solution has the advantage that it can be worked in an unlined steel vat, as it does not attack this material.

As previously stated, it is necessary to have a small amount of "free" cyanide. This means that there must be a certain amount of additional cyanide over the minimum quantity necessary to maintain a clear solution. Cuprous cyanide itself is insoluble in water, but it dissolves in an excess of alkali cyanide, forming a complex to which the formula KCu(CN)_2 is usually assigned, although there is indication that the complexes $\text{K}_2\text{Cu(CN)}_3$ + $\text{K}_3\text{Cu(CN)}_4$ also exist. This double cyanide is soluble but if there were not free cyanide present,

it is quite obvious that when the anode began to dissolve in the solution, as the result of the electrolytic action, an excess of cuprous cyanide would be formed and this would form as a green sludge at the anode which would prevent its further solution and make it impossible to get a satisfactory circuit through the cell. This may happen if sufficient free cyanide is not present. On the other hand, if too much cyanide is added there will be a tendency for the amount of copper deposited to be reduced, that is to say, the current efficiency of the process will drop, and a large amount of hydrogen but very little copper will be produced. If the solution is to work satisfactorily, the free cyanide must be carefully controlled so that there is sufficient free cyanide present for the anodes to work satisfactorily, but not enough to upset the deposition processes at the cathode. This free-cyanide content can sometimes be controlled by carefully observing the colour of the solution and the action at the two electrodes, but it is preferable to control it by analytical methods.

Cyanide is a somewhat unstable substance, and a prolonged heating or exposure to the atmosphere tends to break it down into carbonates and other materials. It is usually found, therefore, that small quantities of cyanide have to be added from time to time to maintain the necessary percentage of free cyanide while the carbonate content of the solution will increase. When this carbonate content increases beyond a certain concentration, trouble may be experienced due to reduction of current efficiency and deposits of unsatisfactory structure. It may then become necessary to remove the carbonate. Several methods have been suggested for doing this, one of the most popular being to freeze it out as this carbonate generally crystallizes out before the remaining constituents. This, however, is more generally done with sodium

salts than with the potassium salt which is rather more soluble.

It need hardly be stressed here that all cyanides are highly poisonous and people who have to deal with these substances in practice should familiarize themselves with the various methods to be adopted for First Aid in the case of poisoning, and also the necessary precautions in handling. These matters, however, do not enter into the intermediate syllabus and will not be dealt with further here.

PLANT

At the Intermediate stage the candidate is required to have a general knowledge of the plant used in electroplating shops. This may be divided into the electrical plant, vats, and pumps, filtering devices, etc. It is intended at this stage that the knowledge should be general only and it is not expected that an Intermediate candidate will have a specialized knowledge on this subject but although it is unlikely that specific questions on plant will be asked, the candidate may be required to give a general description of the plant required to carry out some particular process on which he is being questioned.

Electrical Plant

For plating and deposition processes a supply of low-voltage direct current is necessary. In the majority of cases the electrical supply will be alternating current at a voltage of 200 to 400 and it is necessary to transform this. Two general methods are employed, (a) a motor-generator set, that is to say an electric motor driving a low-voltage direct-current generator, and (b) a plating rectifier, that is to say, a transformer to reduce the voltage to the required value coupled to a metal

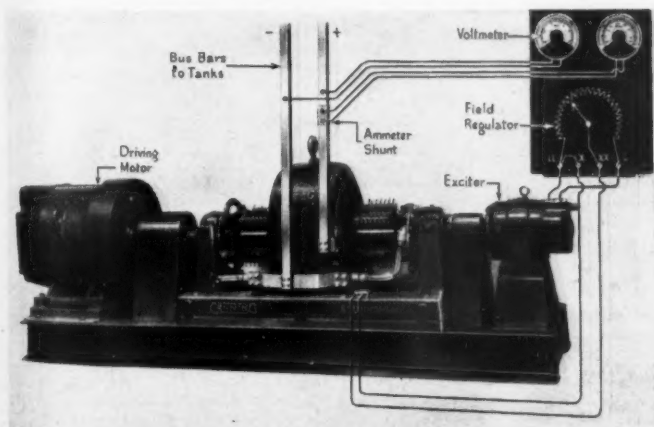


Fig. 1.—15-v. 200-amp. motor generator showing bus-bar connexions and connexions to control panel.

(Courtesy W. Canning and Co. Ltd.)

rectifier which converts the alternating to direct current.

Motor Generator

The motor-generator set as mentioned above, consists of an electric motor designed to work off the mains voltage, driving a special dynamo suitable for producing the plating current (Fig. 1). This dynamo is characterized by the fact that it will have a large commutator, because it has to produce a high current at a low voltage, and therefore the commutator must be sufficiently large to carry the required current without undue voltage drop. These generators are also provided with special brushes containing copper dust so as to reduce their resistance. It is not proposed here to discuss the theoretical action of a generator as this should have been learned in the physics course. It may, however, be stated that the majority of these generators are shunt wound, but are often provided with series interpoles so that the voltage does not vary unduly as the current from them is increased. The shunt winding is not normally excited directly by the generator itself, but is specially excited either by a small exciter generator, connected on the same shaft, or by a metal rectifier set working directly from the mains. The exciter voltage is generally of the order of 200 volts, the field coil to the dynamo being wound for this voltage. The reason for this is that it is very much easier to control the dynamo when it is separately excited, as otherwise the current tends to build up or slowly drops when an adjustment is made to the field regulator and the voltage will vary very much with the current being taken from the apparatus. The voltage of the generator is usually controlled by a variable resistance placed in the field circuit.

Plating Rectifier

These rectifiers are becoming increasingly popular and are largely used on most of the modern plants. The alternating current supply from the mains is first transformed to the required voltage and is then rectified by means of special plates composed of a layer of selenium on a copper

Fig. 2.—Diagram of wiring arrangement of a three-phase full-wave rectifier.

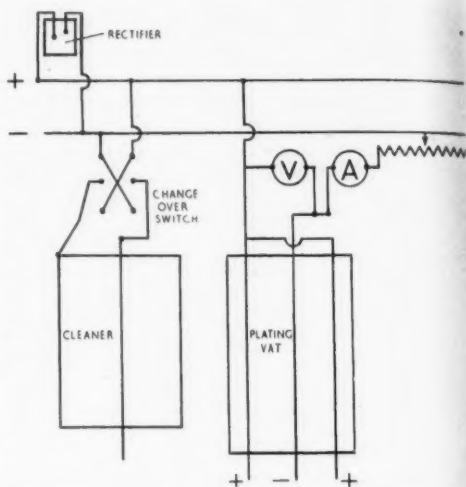
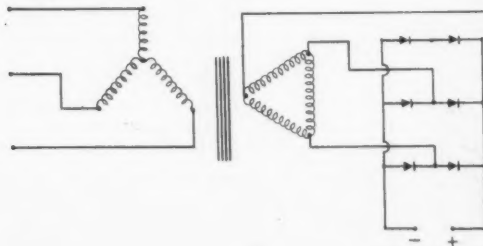


Fig. 3.—Diagram of method of wiring current supply to cleaner tank and plating vat.

surface. These plates have the property of allowing an electric current to pass through them in one direction, but preventing it from passing through in the opposite direction. They act in effect as a non-return valve. If a number of these plates are arranged as shown in Fig. 2, it will be seen that when one wave of the alternating current enters the apparatus a current is produced in one direction at the output terminals, but as the opposite wave enters, due to the action of the rectifying plates, current will still leave the apparatus in the same direction. Those who have constructed radio sets will be conversant with this principle.

Fig. 4.—A typical manually operated plating vat shown here in use for electrolytizing.

(Courtesy W. Canning and Co. Ltd.)

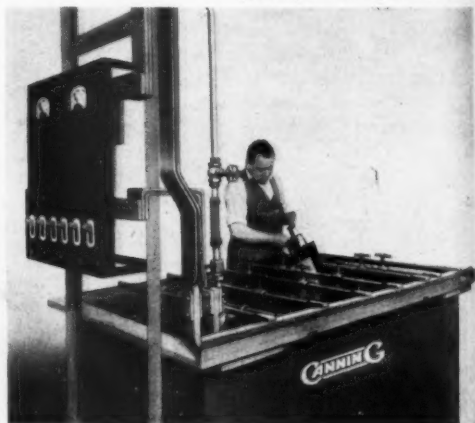


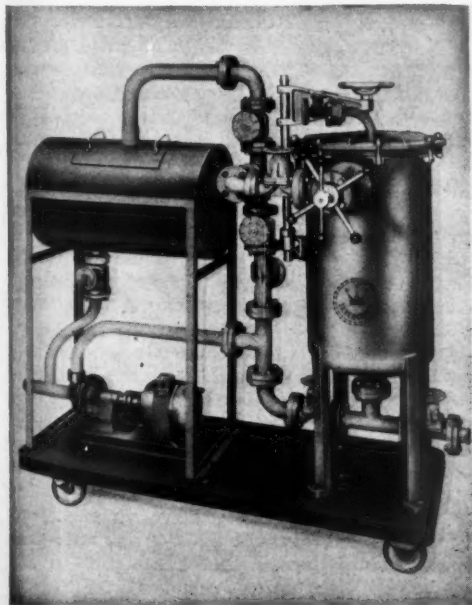


Fig. 5 (Above).—A battery of chromium plating tanks showing the associated exhaust fans and ducting fabricated for the greater part in this case in P.V.C.

(Courtesy R. Cruickshank Ltd.)

Fig. 6 (Below).—A typical pump and filter unit.

(Courtesy Silvercrown Ltd.)



Plating rectifiers may be arranged to work off single-phase or three-phase supplies. The output voltage of the rectifiers may be controlled either by tapings on the primary wiring of the transformer or by use of a subsidiary transformer, regulating the voltage of the primary current. In practice transformer and rectifying unit are assembled in a large steel tank provided with cooling pipes and filled with oil. They have thus no moving parts and may conveniently be situated near to the plating vat. When installing, however, care must be taken to see that they are sufficiently well ventilated, because if they become overheated the plates may be damaged.

Distribution of Current

In addition to the apparatus used to produce the low-voltage current required, it is necessary to have a system of copper bars to distribute the current to the various plating tanks and if it is desired to run more than one tank from one generator or rectifier, separate control resistances will be required and meters for reading both current and voltage should be fitted to each vat. A diagram of vat connexions is shown in Fig. 3.

Plating Vats

It is apparent that the plating solution must be contained in some type of vat which will not be attacked by it. It is sometimes less obvious but in point of fact just as essential that the material of which the vat is made or lined shall not contaminate the plating solution.

Acid solutions are normally worked in lead-lined tanks. Polythene, P.V.C. and other plastics are being used to some extent for lining tanks for this purpose. Stoneware vats are also used.

Some difficulty may be experienced with certain solutions due to contamination of the solution, either by the lead lining or by certain substances present in rubber linings. It is not expected that an Intermediate candidate will have any special knowledge of these troubles beyond the knowledge that such danger does exist.

Alkaline solutions are normally used in unlined steel vats. Silver-cyanide solutions, however, are often used in lead-lined vats, or sometimes in rubber, and gold solutions are generally contained in vitreous-enamelled steel vats. Cleaning tanks are for the most part made of steel and may be heated directly, either with steel steam pipes or gas flames beneath them. Plating vats may be heated if required, by steam coils made of suitable material, water jackets, or immersion heaters having jackets inert to the solution in question. Plating vats will also be supplied with bars on which to hang the anodes and objects to be plated. Vats for chromium plating must be exhausted by fixing long ducts down either side connected to a centrifugal fan.

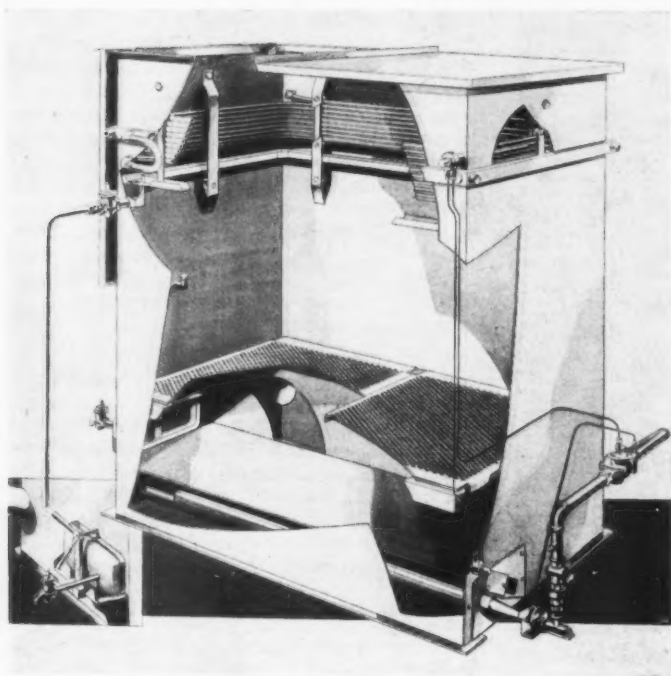


Fig. 7.—Gas-heated vapour degreasing plant.

(Courtesy of I.C.I. Ltd.)

For preliminary cleaning a trichlorethylene degreaser is used. This apparatus consists of a steel tank with cooling coil through which water can be circulated, arranged around the top. Some method of heating is provided, the arrangement being that the trichlorethylene is boiled in the bottom of the tank and the vapour which is heavy, slowly rises upwards until it comes in contact with the cooling coil which condenses it so that the liquid drops back into the bottom of the tank. When an article is placed in this vapour, it condenses on the article dissolving the grease and carrying it down into the sumps.

Pumps, Filters, etc.

The design and operation of pumps and filters is somewhat outside the Intermediate syllabus. The candidate should be aware that certain solutions may require filtering either from time to time or continually, and that special pumps and filters must be used for this purpose. It is, of course, quite obvious that the pumps and filters employed must not be attacked by the solution and must not contaminate it. Normally either Mono-pumps, diaphragm pumps or centrifugal pumps are used for pumping the solution and filter presses, or special filters designed to form a bed for a filter aid, such as kieselguhr, are used. Details of this plant, however, are outside the

present syllabus and will not be discussed here.

Agitation of Solution

The majority of solutions requiring agitation are agitated by blowing air into the bottom of the tank and allowing it to rise through the solution from a perforated pipe. In some cases where air agitation is unsuitable, some types of cathode rod movement or impeller may be used. In certain cases it is found more convenient to move the article on which the deposit is being made, rather than the solution. This is particularly so in the case of such articles as cylinders which can be easily rotated.

The term "agitation" is generally used to describe rapid movement of the solution but where the solution is simply being pumped round a certain system at a comparatively slow speed, this is generally referred to as circulation, and is done to keep the composition of the solution constant through the system.

As previously mentioned a detailed knowledge of plating plant is not required in the Intermediate syllabus, and the above outline of plant will be sufficient. The final candidate is, of course, required to have a very much more detailed knowledge, but this matter will be discussed again when dealing with the Final syllabus.

(Series to be continued)

FINISHING

NEWS REVIEW

I.M.F. HAS SUCCESSFUL YEAR

Activities Reviewed at Annual Meeting

AT the Annual General Meeting of the Institute of Metal Finishing held at the Charing Cross Hotel on November 14, the Honorary Treasurer, Mr. F. L. James, was able to report a financial surplus on the year's workings. This represented the fruits of the increase in the membership subscription rates and was a satisfying improvement on the deficit which had been reported in previous years.

The report of the Council for the previous session was presented by the Honorary Secretary, Dr. S. Wernick. This showed a very active year in all branches, while the Annual Conference which had been held at Torquay, had again broken all existing records for attendance and number of technical papers presented. Dr. Wernick expressed regret that for the first time for many years it was necessary to record a net loss of membership during the past year. This had not been unexpected as a result of the increase in membership subscription and gave no real cause for concern. He was however, concerned at the drop in the intake of new members during the session, which was the lowest recorded during the past five years. He urged on all members to do their best to draw the attention of potential members to the advantages of membership of the Institute.

Following the presentation of the report of the Council, the election of Honorary officers and Council for the ensuing year was announced. These details have been reported in an earlier issue of this Journal.

At the conclusion of the formal business, the meeting proceeded to discuss a recommendation sponsored by the Education Committee that Council should investigate in association with other appropriate bodies the means of establishing a Nationally approved apprenticeship scheme for trainees in the metal finishing industries. Members present at the meeting made a number of constructive observations on the substance of this recommendation and at the conclusion of the meeting the consensus of opinion clearly gave Council a mandate to investigate the possibilities of such a scheme, although it was equally clearly felt that the Institute of Metal Finishing was not the appropriate body to be the prime mover in negotiating its adoption.

Following the meeting, members attended a luncheon at which a small number of guests was entertained by the Institute. The principal guest, Dr. Maurice Cook, President of the Institute of Metals proposed the toast of the Institute of Metal Finishing, to which Professor J. W. Cuthbertson responded. In the course of his reply Professor Cuthbertson proposed the health of the newly elected president, Mr. R. A. F. Hammond, whose ceremonial induction was to be staged at the afternoon meeting.

Presidential Address

After his induction Mr. Hammond delivered his presidential address on "Research and Industrial Application in Metal Finishing."

During the course of his address, Mr. Hammond outlined the existing facilities in this country for fundamental research into the field of metal coating, and expressed the view that it appeared possible that, in so far as the practical day-to-day needs of the metal finishing industry were concerned, not enough money was being spent on research, especially by the smaller organizations, although the basic facilities for such research exist and could presumably be expanded.

Unfortunately however, he was unable to determine the existence of any ready remedy for the solution of difficulties associated with bridging the gap between research and application, while it was clear that unless this could be effectively achieved, the money and effort expended on research would be wasted. Mr. Hammond said that he deprecated the apparent increasing tendency to use American processes, many of which had been launched on the market in recent years in an incompletely developed state. The regrettable delay, which had also been evident in commercializing such potentially valuable processes as

Fifty Years of Monel

Henry Wiggin Jubilee

MONEL metal, an alloy containing approximately 70 per cent nickel and 30 per cent copper was discovered in 1905, and to celebrate its 50 years of production, Henry Wiggin and Co. Ltd., held a press conference on Friday November 11, at which Mr. I. A. Bailey, managing director of the company gave some brief details of the alloy's history.

Originally, Mr. Bailey said, the nickel and copper were separated by an ingenious process, the Orford "tops and bottoms" process, from nickel-copper ores owned by the International Nickel Co. Ltd., at its mines near Sudbury, Ontario.

It was then discovered that the nickel-copper ore could be directly treated to provide a wrought nickel-copper alloy.

The alloy was found to possess properties which were lacking in many of the more common materials used in industry at that time. It was for example, as strong as mild steel, and resistant to attack by sulphuric acid, sea water and high-pressure steam.

The many uses of Monel today range from hypodermic-syringe needles to the tubes of high pressure inter-stage superheaters. One of the more interesting uses of Monel is for the stays of locomotive boilers, and its wide application for pickling crates is an example of the high-corrosion resistance of the alloy.

chemical and electrochemical polishing or tin-nickel and other alloy-plating processes could also be attributed to inadequate development work. Mr. Hammond cited the fact that Brenner's original work on the electroless deposition of nickel had been published in 1946, and it was only very recently that this process had received commercial attention in this country.

At the end of his address the new president drew attention to the ways in which the Institute might expect to contribute towards the stimulation of technical developments in metal finishing in this country, and outlined some of the work which would have to be tackled in the period of consolidation which he foresaw as being characteristic of his period of office.



OLD ESTABLISHED NEW WORK

Increased Hot-dip Galvanizing Capacity for Frederick Braby and Co., Ltd.



ESTABLISHED in 1839 in Tottenham Court Road, London, the business now carried on by Frederick Braby and Co. Ltd., has continued to expand until today the company has works at Liverpool, Glasgow, Bristol and Crayford. The new Crayford works, recently visited by members of the technical press and leading industrialists as part of the celebrations of its completion and occupation, covers nearly 12 acres on a site of about 28½ acres. The buildings of this modern works have been laid out so that materials enter the stores at one end either by road or rail then pass through the various manufacturing processes and finally arrive at the dispatching department at the other end.

The workshops are constructed on the north-light principle and many of the company's products are incorporated in the construction and equipment of the works and offices, including steel windows and staircases, galvanized steel gutters, water tanks and cisterns, cable trunkings, work's offices, and lockers for clothes. A feature of the offices is the company's Bar-Form partitioning. The Mansard roof of the office building was covered in copper by the company's metal-roofing department.

Galvanizing Shop

The galvanizing shop in the Crayford works, 400 ft. long × 130 ft. wide × 22 ft. 6 in high, is laid out on straightforward "flow" lines, starting with acid pickling in hydrochloric acid, then water washing to remove any acid salts adhering to the work. A dip in flux solution follows, after which the work is dried in conveyORIZED drying ovens prior to dipping in the molten zinc. Any work which requires water and pressure testing, is then passed over to the testing bay.

The galvanizing furnaces are fired by coal through underfeed stokers which are completely automatic and controlled by in-



(left) A general view down the hot-dip galvanizing line at the new Crayford works of Frederick Braby and Co. Ltd. (left, above) A large water storage tank being removed from the galvanizing bath.

THE COMPANY OCCUPIES MARKET CRAYFORD



Aerial view of the new works at Crayford.

struments, located in the supervisor's office, which control both the bath temperature and the heat of the flue gases. After leaving the bath surplus heat is conveyed by flues under the floor to the drying ovens and discharged eventually through an external chimney. Contractors for the galvanizing plant were Thompson Bros., Bilston and G.C. Engineering Co. Ltd., London.

Ventilation of the shop is by 22 extract fans, and heating is by unit heaters from the boiler house. Battery unit heaters are provided in the walls, blowing fresh warmed air into the shop. Monorails are provided over the small acid and galvanizing baths with electric travelling and hoisting blocks. Over the large baths four cranes are available; these are push-button operated from the floor. The cranes have two-speed hoisting and lowering, the standard speed used for withdrawing components from the galvanizing baths being 5 ft. per min.

Although only three galvanizing baths are at present in use (one 8 ft. x 4 ft. x 7 ft. 6 in., one 8 ft. x 4 ft. x 4 ft. 6 in. and one 16 ft. 6 in. x 6 ft. 6 in. x 6 ft. 6 in.) space has been left for the installation of a fourth bath when required. The baths operate at a temperature of 445 to 465°C. according to the type of work.

Separate washing and lavatory

accommodation is provided for the picklers and galvanizers, together with shower baths, and there is a drying room for clothes and a night mess-room

Neutralizing Plant

All the acid from the pickling shop is dealt with in this department, and meets the requirements of the local Sewerage Authority—who insist that any effluent discharged into their sewer should be approximately neutral (7 to 10pH) and should contain not more than 50 grains per gallon solid content. The plant consists of a main acid-collecting sump, taking the discharge from the factory. A rubber-lined pump sends acid to two outside neutralizing and storage tanks, 16 ft in diameter and provided with agitators. An outside pit collects the spent carbide residue from the acetylene generators, and this sludge flows into the neutralizing tanks. When the pH test meter shows that neutralization of the acid is complete, the liquor content of the tank is pumped up into either or both of the sludge filter presses. The press forms the solid matter into a cake and the liquid, now neutral, is discharged into a final settlement tank outside.

The clear liquid overflows the weir of this tank via a flow meter, either to the industrial drain or is pumped up to the wash-water storage tank in the Tower.

This plant was manufactured by Thatcher Lucas Ltd., Bilston.



PREMIUMS FOR TECHNICAL WRITING

NON-PROFESSIONAL writers of technical articles dealing with radio and electronics, including specialized applications to any industry are reminded by the Radio Industry Council of its premium award scheme.

Up to six premiums of 25 guineas each are offered yearly in respect of articles which are likely to enhance the reputation of Great Britain in radio, television and electronics.

Many industries are increasingly using electronic methods of control and production and articles in the journals serving a wide variety of industries are eligible provided they can be bought by the public on bookstalls or by subscription. Industries specifically concerned are the motor, aircraft, metal-working, wood-working, and food industries.

An innovation now announced is that one of the six premiums will be open for articles published in manufacturers' own journals with an overseas circulation, provided they also can be bought by the public. Articles in privately published journals of professional bodies are not eligible.

Object of the scheme is to encourage a greater flow of articles from within industry, but any writer is eligible provided he is not paid wholly or mainly for writing and is not earning more than 25 per cent of his income from fees for articles or book royalties.

The judges, headed by Professor H. E. M. Barlow, Professor of Electrical Engineering, University College, London, believe that an article, to have maximum impact, should have a non-technical introduction setting out the aims and applications of the techniques described and if possible economic advantages, the object being to interest executives and administrators as well as scientists and engineers. Value of the article in making known British achievement, originality, technical interest and presentation and clarity are the criteria.

To enter, copies of the journal or pages have to be sent before the end of the year to the Secretary, Radio Industry Council, 59 Russell Square, London, W.C.1, with a written declaration that the writer is eligible.



Meetings of the Month

November 16

Institute of Metal Finishing. "Modern Painting and Stoving Techniques, Including Flow Coating" by J. J. Stordy, B.Sc., and W. G. J. Appleton, A.M.I.Mech.E., M.Inst.F., at the Mason Theatre, Birmingham University, Edmund Street, Birmingham. 6.30 p.m.

November 18

Society of Chemical Industry. "Symposium on the Protection of Cable Sheathing." "The Phenol Corrosion of Lead" by R. L. Davies and E. L. Coles, "Cathodic Protection of Telecommunications Cables" by J. Gerrard and J. R. Walters, "The Protection of Buried Power Cables" by J. H. Gosden, "The Behaviour of Aluminium Cableheaths" by P. A. Raine and "The Mechanism of Corrosion of Metal Pipes in Soils and Practical Methods of Prevention" by W. W. Robson and A. R. Taylor, at the Institution of Electrical Engineers, Savoy Place, London, W.C.2. 10 a.m., 2.30 p.m., and 5.15 p.m.

November 21

Institute of Metal Finishing (London Section). "The Use of the Electron-microscope in Electrochemical Research" by A. Mohan, M.Sc., "The Application of Technical Studies to Industrial Experience" by D. I. C. Kapp, "The Kinetics of Electrodeposition of Metals" by D. M. Gilbey, at the Imperial College, South Kensington, London. 6.15 p.m.

November 24

Institute of Vitreous Enamellers Ltd. (Midland Section). "What is Frit" by N. S. C. Millar at the Birmingham Exchange and Engineering Centre. 7.30 p.m.

Incorporated Plant Engineers (Sheffield and District Section) "The Treatment of Effluents" at the Grand Hotel, Sheffield. 7.30 p.m.

December 1

Birmingham Metallurgical Society "Presentation of Metallurgical Information" by J. W. Jenkins, Ph.D., B.Sc., F.R.I.C., F.I.M., at the Lecture Hall, James Watt Memorial Institute, Great Charles Street, Birmingham, 3. 6.30 p.m.

Institute of Metal Finishing, N.W. Section. "Treatment of Effluents and Effluent Disposal" by J. McNicholas, B.Sc., F.R.I.C., M.Inst.S.P. at the

TRADE and TECHNICAL PUBLICATIONS

Hard Anodizing of Aluminium: An article in the October 1955 issue of "Aluminium News" published by Aluminium Ltd., deals with the several methods on the American continent used for the hard anodizing of aluminium. Most commonly known are the Martin Hard Coat (MHC), Alumite Hard Coating and the Hardas (Hard Aluminium Processes Ltd.) processes. Each produces an anodic coating which is a hard porous film of aluminium oxide with an average Rockwell hardness of C.40. The major difference between these processes and the normal anodizing processes is that the latter are effected by lower current densities and higher temperatures. A chromate seal on certain of the hard-coated alloys results in an improved fatigue strength.

A more recent process has been developed by the Sanford Process Co. Inc., by which the oxide film can be obtained in a short time. For example, a 6-mil. coating is produced in only 55 minutes. Furthermore a hardness of Rockwell C.50 to C.58 is obtained.

A process attracting attention in the U.K. is that developed by Dowty Equipment Ltd. This process has proved particularly effective for such items as sliding tubular members for aircraft undercarriages, and other sliding surfaces operating at fairly low speeds.

Shotblasting: A guaranteed 24-hour service in shotblasting is the claim of R. J. Richardson and Sons Ltd. Commercial Street, Birmingham, 1. Established in 1887 this company

impose no restrictions on the size of the job or the materials being processed. The company also carry out shot-peening and wheel - a - peening, and technical representatives are at a customer's call to discuss problems. Full details of the services offered by the company are given in a brochure recently published.

* * *

"Telling Industry's Story Overseas": This booklet, published by The Federation of British Industries, 21, Tothill Street, London, S.W.1. (Price 3s. 6d. net.) describes how the story of British industry can be told in export markets overseas. It deals with the ways (other than advertising) in which news about industry, its products and achievements, can be got into newspapers, technical and trade journals, radio, television and films in countries all over the world. The channels for this purpose, office and non-official are open to any firm wishing to use them, but hitherto there has been no ready guide to their use. The F.B.I. Publicity Committee has endeavoured to fill the gap by preparing this booklet.

Chapter 1 describes the final outlets through which a story can reach the public, or a particular section of the public, in overseas markets, while Chapter 2 describes the various channels of communication through which a story can be distributed so as to reach the final outlets. Finally, in Chapter 3, some practical suggestions are made as to how to use these different channels.

Engineers' Club, Albert Square, Manchester. 7.30 p.m.

December 5

Bradford Engineering Society. "The Protection of Metal by Paint" by R. A. W. Ottley, followed by a film entitled "The Technique of Paint Spraying at the Bradford Technical College". 7.15 p.m.

December 6

Institute of Metal Finishing (Midland Section). "Chemical Brightening of Aluminium" by A. W. Brace, A.I.M., at the James Watt Memorial Institute, Great Charles Street, Birmingham, 3. 6.30 p.m.

December 7

Institution of Chemical Engineers (N.W. Branch). "Phenolic Effluent Disposal" by D. A. Hall at the University, Leeds. 7 p.m.

Institute of Industrial Supervisors (West Bromwich Section). "Is a Superfine Finish Necessary?" (a continuation) by A. S. Tooke at the Kendrick Technical College. 7.45 p.m.

December 8

Institute of Metal Finishing (N.W.

Branch) joint meeting with the Liverpool Metallurgical Society. "Some Aspects of Electroplating Relative to Industrial Applications" by A. W. Wallbank, B.Sc., F.R.I.C., at the Engineers' Club, Albert Square, Manchester. 7.30 p.m.

December 9

Institute of Metal Finishing (London Branch). Annual Dinner and Dance at the Waldorf Hotel, Aldwych, London, W.C.2.

December 13

Incorporated Plant Engineers (Manchester Branch). "Corrosion Technology" by a speaker from the Mond Nickel Co. Ltd., at the Engineers' Club, Albert Square, Manchester. 7.15 p.m.

December 14

Society of Chemical Industry (London Branch). Joint meeting with the Organic Finishing Group of the Institute of Metal Finishing. "Chromate Pigments for Metal Protection" by H. G. Cole, at the Chemical Society, Burlington House, Piccadilly, London, W.1. 6.30 p.m.

Latest Developments in

PLANT, PROCESSES and EQUIPMENT

Heavy-duty Three-speed Sander-Grinder

THE 7-in. heavy-duty sander manufactured by Black and Decker Ltd., Harmondsworth, Middlesex, has now been replaced by a completely new machine which delivers 90 per cent more power and yet is lighter in weight. Known as the 7-in. heavy-duty optional-speed sander-grinder, it is available in three models with spindle speeds of 4,200, 5,200, and 6,000 r.p.m., each unit being designed for a specific range of work. Thus the low-speed and standard models are suitable for use with planer heads for wood, saucer grinding wheels, wire cup brushes, and sanding discs, while the high-speed machine has been designed primarily for use with nylon-bonded depressed-centre cutting-off wheels. These wheels require high speeds and constant power for satisfactory operation and are extremely versatile. It is possible to rough grind, finish grind and notch a wide range of

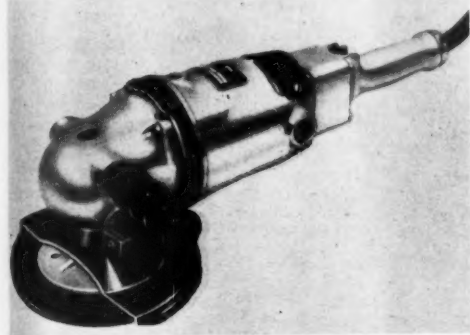


Fig. 1.—Sander-Grinder

materials ranging from cast iron to marble with the same wheel.

The motor of the machine has completely protected brush gear, grease-sealed ball bearings, heat-treated spiral gears, etc., among its many features.

Some of the applications for this new tool when fitted with a depressed-centre disc include cutting-off gates and risers on ferrous and non-ferrous castings, grinding down welds on railway wagons and coaches, smoothing flame-cut edges on heavy steel plates, cleaning between the teeth of heavy industrial and marine gears, cleaning off rust and scale from girders and rails, scurfing and bevelling prior to welding, cutting sheet metal for motor vehicle panels, refacing die and press blocks, removing rivet and bolt heads, cutting off angle iron, cutting insulating material to size, and cutting off magnesite and high-alumina refractory bricks.

Owing to the construction of these discs they show great economy in use. In addition, they are extremely robust and wheel breakages are negligible. To ensure perfect safety, however, two wheel guards are available; these are manufactured to suit 7- and 9-in. diameter depressed-centre wheels. They are designed to clamp on to the spindle bearing boss of the tool and are held in position by means of a clamp and fixing bolts.

Moulded rubber backing pads are available for both sizes of discs, and the net weight of the machine is 14 lb.

"Mist-free" Paint Spraying

ONE of the major disadvantages of spray painting is the wastage of paint due to overspray. The "Jzet" low-pressure compressor and spray gun marketed in this country by British Universal E.M.E. Ltd., 36, Victoria Street, London, S.W.1., is claimed to make "mist-free" spraying of all media a practical reality, resulting in a saving of paint of about 40 per cent. The operating principle of the equipment is that it makes use of a large volume of air (approximately 50 cu. ft. per min.) at a low pressure, 4 lb. per sq. in., instead of the usual high pressure air. Paint is normally used at the usual spraying viscosity, subject to adjustment in certain cases. Spraying can be carried out *in situ* with a minimum of masking and protective clothing, and through the absence of overspray the health of the operator is protected. The quantity of paint can be regulated exactly as desired and the media reach the surface being sprayed in the correct consistency, a particular advantage when painting large surfaces. By the use of the appropriate needle and nozzle the equipment is suitable for the application of all sprayable products, e.g. cellulose and glycerophthalic lacquers, varnishes, oil paints, chemical products, liquid greases and oils, plastics, etc. The equipment is completely portable.

Fig. 2.—Low-pressure paint-spraying equipment



Diecast Pressure Paint Container

SMOOTH lines leading to ease of cleaning and maintenance are important factors in the design of paint pressure pots.

Alfred Bullows and Sons Ltd., Long Street, Walsall, Staffs, now offer a 2-gallon pressure paint container (Fig. 3) of entirely new design and construction. The shell of the container, as well as the cover, is in the form of a high-tensile aluminium-alloy diecasting, and replaces the conventional galvanized welded mild-steel shell. This shows a substantial saving in weight, and most important, gives a perfectly smooth surface both inside and out, making cleaning of the container a very simple matter. This is an important advantage whenever it is required to use the container for a variety of different coloured paints.

The cover is held in position by forged steel "C" clamps and handscrews, enabling it to be quickly and easily removed. The material feed pipe is Duralumin. This means that all parts in contact with the paint are of aluminium alloy or stainless steel. There is no brass or mild steel used internally at all.

The container is available with or without a pressure-reducing valve unit, which is flange mounted on the cover and houses the shrouded pressure gauge. It has a built-in safety valve which has an easing ring, so that it is used as a blow-off valve, and is non-adjustable. The container will also be available with a galvanized mild-steel shell, for use with materials corrosive to aluminium.

Fig. 3.—Paint Pressure Pot



All containers are for a maximum working pressure of 50 lb. per sq. in. and are hydraulically tested to 100 lb. per sq. in.

Pencil-type Surface Roughness Scales

RUBERT AND CO. LTD., Chapel Street, Stockport Road, Manchester, 19, are manufacturing surface roughness standards which can be clipped to a pocket in the same way as a pencil. The standards consist of specially selected hexagonal stainless steel 1 in. in length, each face being $\frac{1}{16}$ in. wide. There are two sections, No. 1 consisting of 1, 2, 4, 8, 16, 32, micro-in. C.L.A., and No. 2 consisting of 63, 125, 250, 500, 1000 micro-in. C.L.A., to B.S.S. 1134:1950. Both sections can be screwed together and fitted into the container as one unit, or, alternatively, these can be supplied as single sections only. There are therefore three models available, viz.: Model 1, 1 to 32 micro-in.; Model 2, 63 to 1000 micro-in.; Model 3, 1 to 1000 micro-in.

Corrosion-Resistant Compound

A NEW development in the field of corrosion-resisting compounds is the production of a fibre-reinforced plastic material which can be applied by brush on metal surfaces as an effective and economical protection against the corrosive effects of aggressive atmospheres, sea-water, hydro-carbon products and

Fig. 4.—Surface roughness scales

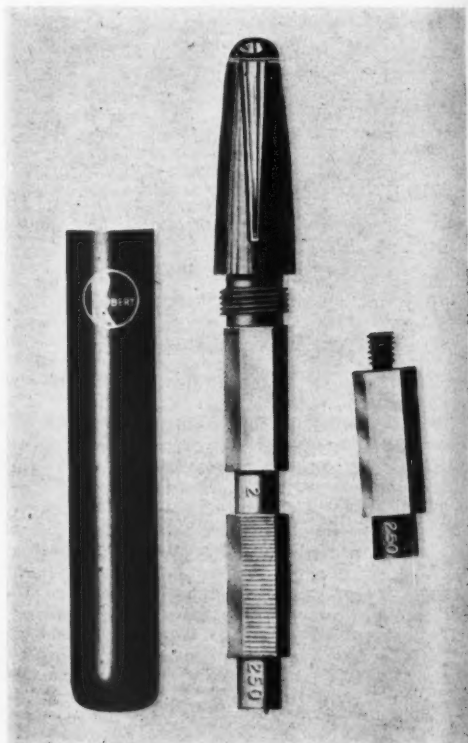


Fig. 5 (a) hydrochloric compound

a wide range of liquid forms.

The material is those chemical compounds consists of high-alloy a tough

It is woven is cold is appropriate claimer treatment loose surface of application. Because this application since corrosion.

The shows a particular favour. The satisfaction. Extra application refined products. The V.G. St., California.

IT is a manufacturing dry cleaning and



Fig. 5 (above).—Shows the effect of suspending a mild steel test plate in hydrochloric-acid fumes for 3 weeks, with and without coating with V.G. compound. The coated side (right) has been wire-brushed clean, and shows no appreciable corrosion.

a wide range of chemical agents, both in gaseous and liquid form.

The material, which will be of special interest to all those concerned with the maintenance of oil refineries, chemical-processing plant and structural steelwork, consists of a mixture of a synthetic resin or latex with high-alumina cement, the whole being reinforced with a tough woven fabric by a patented process.

It is applied in two layers, interspersed with the woven fabric, to a total thickness of about $\frac{3}{8}$ in. It is cold setting, and the weight of the complete coating is approximately 9 lb. per sq. yard. One advantage claimed for this technique is that very little preparatory treatment is required. It is sufficient to remove loose scale and rust by wire brush, and the presence of moisture does not impair the effectiveness of the application.

Because of the toughness of the layer produced, this "V.G. Compound" is likely to be particularly applicable for structures composed of thin sheeting, since it will afford them extra strength as well as corrosion protection.

The compound is impermeable and yet flexible, shows no softening at elevated temperatures and has a particularly good impact strength, comparing favourably in this respect with standard concrete. The adhesion strength is also said to be very satisfactory.

Extensive initial tests have been carried out on the applicability of this material in shipyards, and in oil refineries in this country and in France, in gas producing plants and also in sewage treatment works.

The "V.G. Compound" has been produced by V.G. (London) Ltd. of 5-6 Newman Passage, Oxford St., W.1, who can carry out large-scale site applications as required.

Hand and Face Dryer

It has been announced by Crypto Ltd., North Circular Road, London, N.W.10, that they are manufacturing the model G.B.1. hand and face dryer (Fig. 6).

The machine, which is pleasingly simple in design and finished in vitreous enamel, is electrically operated



Fig. 6 (right).—Hand and Face Dryer.

by a foot pedal. When the pedal is depressed, a stream of air is blown over a heating element, then out through two nozzles. In these streams of pleasantly warm air, the hands and face are quickly dried in a hygienic manner. The patented drying head perfects the face-drying process and thus makes this appliance a complete substitute for linen or paper towels.

This new model is competitively priced and running costs and maintenance are low by comparison with the expenses of other methods of hand and face drying.

Magnetic Filter Units

THE removal of traces of iron picked up by materials during processing is a necessary step in many industries. It is a particular necessity in the case of modern titania-opacified enamels where the presence of iron can give rise to severe yellowing of white frits. It is in consequence standard enamel mill-room procedure to pass all slurry through magnetic filters.

"Blencut" permanent-magnet filter units, which operate with powders or liquids, are easily cleaned, have high extracting efficiency and are easily installed, are manufactured by the Blending Machine Co. Ltd.,



Fig. 7.—Magnetic Filter Unit.

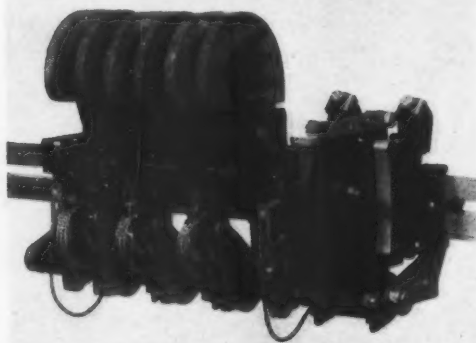
Bond Street, Hockley, Birmingham, 19. The units (Fig. 7) comprise two high-intensity permanent magnets which are situated horizontally, between the poles of which is situated a non-magnetic filter casing fitted with ferrous grids. The grids become magnetized under the induced flux from the two magnet units and as the material to be processed is passed through the grids any ferrous particles adhere to the grids leaving the purified material to flow through. When it becomes necessary to clean the grids off, the filter casing can be removed so causing the grids to become non-magnetic thus allowing the ferrous particles to fall away. If required, *e.g.*, where the material being handled is not free-flowing, a vibratory unit can be attached to facilitate the flow but without reducing the strength of the magnetic field.

These filters are available in four different sizes, and the grids are also manufactured in different types and sizes to suit the varying characteristics of the materials being handled. The manufacturers recommend that in order to determine the most satisfactory type of grid, a sample of the material to be processed is submitted to them for test.

Contactor Switchgear

It is now widely recognized that manual operation of switchgear is unsatisfactory, except in the case

Fig. 8.—Contactor Switch.



of very small power loadings, as high-speed make and break is necessary to avoid damage to contact surfaces by arcing. Use is now made of contactor switchgear which makes possible switching of current supplies under very closely controlled conditions. The fact also that such contactors are operated by remote push-button control makes it possible to incorporate interlocking control systems with consequent increase in safety of operations.

Claiming improvements in several particulars the Electric Construction Co. Ltd., Bushbury Engineering Works, Wolverhampton, has recently announced an extended range of automatic control gear by the addition of a new series of heavy-duty contactors (Fig. 8) made in capacities up to 750 amp. a.c. and 1,000 amp. d.c. These contactors have completed mechanical tests of 5,000,000 operations and also electrical make-and-break tests on eight times the normal full-load current, consisting of 100 operations at 3-sec. intervals.

Unit assembly is an important feature of these contactors, and all the parts are interchangeable and self-aligning with single-bolt fixing. The contacts may be either of solid copper or silver faced. The voltage coil is wound to enable it to be used safely on a wide range of voltages. There is a quick-release magnet spring, and a powerful magnetic blow-out for either a.c. or d.c. service. A quick-acting release enables inspection and service to be readily carried out; the terminals are easily accessible from the front.

The contactors can be provided with push-button stations or other master-control devices. The range includes a diaphragm-type timing-device so that contactors can be built into motor control equipments in the direct-on, star-delta, auto-transformer and stator/rotor types.

The contactors are designed for a complete range of assemblies and customers can purchase separate poles, auxiliary switches, etc. to assemble into any required combination. They are designed for ready assembly into customer's control boxes, into machine-tools or other such equipments and are fully described in brochure S.830 obtainable from the company.

Classified Advertisements

Prepaid rates: FIFTEEN WORDS for 7s. 6d. (minimum charge) and 4d. per word thereafter, or 24s. per inch. Box number 2s. 6d., including postage of replies.

FOR SALE

COMPLETE NICKEL/CHROME PLATING PLANT, in excellent condition for sale — comprising:—5 nickel vats, lead lined with loose plastic lining, steam heated with rocker movement and knife switches. One rotary chromium vat by Canning, 7 feet diameter complete with ammeters and extraction units. One rectangular chromium tank 9½' x 4' x 4' complete with rods and extraction units together with all necessary swill vats. 3 filter units, Mono pumps, one automatic time switch and the necessary rectifiers.—This plant can be viewed by appointment. Apply Box No. 513, METAL FINISHING JOURNAL.

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